TOTAL MAXIMUM DAILY LOADS (TMDLs)

For Chlordane, Dioxins, and Polychlorinated Biphenyls (PCBs) in the Mississippi River

Mississippi River Watershed (HUC 08010100)

Dyer, Lake, Lauderdale, Tipton and Shelby Counties, Tennessee

FINAL

Prepared by:

Tennessee Department of Environment and Conservation
Division of Water Pollution Control
7th Floor L & C Annex
401 Church Street
Nashville, TN 37243

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DEPARTMENT OF ENVIRONMENT & CONSERVATION

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ATSDR	Agency for Toxic Substances and Disease Registry
ADB	Assessment Database
BCF	Bioconcentration Factor
BMP	Best Management Practices
CDD	Chlorinated Dibenzo-p-Dioxin
CDF	Chlorinated Dibenzofuran
CFR	Code of Federal Regulations
HHC	Human Health Criteria
HUC	Hydrologic Unit Code
LA	Load Allocation
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristic
MS4	Municipal Separate Storm Sewer System
NHD	National Hydrography Dataset
NPL	National Priorities List
NPS	Non-point Source
NPDES	National Pollutant Discharge Elimination System
PCB	Polychlorinated Biphenyl
PPB	Parts per Billion
PPM	Parts per Million
PPQ	Parts per Quadrillion
PPT	Parts per Trillion
RM	River Mile
TDEC	Tennessee Department of Environment & Conservation
TEF	Toxic Equivalent Factor
TMDL	Total Maximum Daily Load
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WLA	Waste Load Allocation
WWTF	Wastewater Treatment Facility

SUMMARY SHEET

MISSISSIPPI RIVER WATERSHED (HUC 08010100)

Total Maximum Daily Loads for Chlordane, Dioxins, and Polychlorinated Biphenyls (PCBs) As Identified on the State of Tennessee's *2006 303(d) List*

Impaired Waterbody Information:

State: Tennessee
Counties: Dyer, Lake, Lauderdale, Shelby, and Tipton
Watershed: Mississippi River Watershed (HUC08010100)
Constituents of Concern: Chlordane, Dioxins, and Polychlorinated Biphenyls (PCBs)

Impaired Waterbodies Addressed in This Document:

Waterbody ID	Impaired Waterbody	Miles
TN08010100001_1000	Mississippi River	24.9
TN08010100001_2000	Mississippi River	40.0
TN08010100001_3000	Mississippi River	45.2
TN08010100001_4000	Mississippi River	74.0
TN08010100001_5000	Mississippi River	10.2

Designated Uses:

The designated use classifications for segments of the Mississippi River addressed in this TMDL include domestic water supply, fish and aquatic life, industrial water supply, irrigation, livestock watering & wildlife, navigation, and recreation.

Target Criteria:

Fish tissue concentrations, calculated from the formulas used for fish advisories, will be used as the target criteria.

Pollutant	Organism only	Water & Organisms
	(mg/kg)	(mg/kg)
Chlordane	0.1142	0.1134
Dioxins	5.0×10^{-6}	5.0×10^{-6}
PCB	0.0200	0.0198

General TMDL Analysis Methodology:

- Composite fish tissue samples were collected and analyzed for the constituents of concern.
- The TMDLs are expressed in lbs/day as a function of flow. To assist with imnplementation, TMDLs are also expressed as a maximum water column concentration (in μg/L) and as a maximum fish tissue concentration (in mg/kg), which are equivalent to the target criteria.
- Waste Load Allocations (WLAs) are derived for point source dischargers of chlordane, dioxins and PCBs.
- Load Allocations are established for non-point sources using a mass-balance approach.

Critical Conditions and Seasonal Variation:

The methodology takes into account that the pollutants are contained in the sediment. The methodology addresses all seasons.

Margin of Safety:

5% (Explicit)

Summary of TMDLs, WLAs, and LAs

Waterbody ID	Pollutant	Allocation to Other States[1]	WLAs[2]	LAs[3]	MOS	TMDLs[4]	Maximum H_2O Column Conc.[5]	Maximum Fish Tissue Conc.[5]
		(lbs/day)[6]	(lbs/day)[6]	(lbs/day)[6]	(lbs/day)[6]	(lbs/day)[6]	(μg/L)	(mg/kg)
TN08010100001_1000	Chlordane	Q_1 * 4.10E-05	0	Q_3 * 4.10E-05	Q_4 * 2.16E-06	Q_4 * 4.37E-05	0.0081	0.1142
	Dioxins	Q_1 * 5.12E-09	0	Q_3 * 5.12E-09	Q_4 * 2.70E-10	Q_4 * 5.39E-09	1.0E-06	5.0E-06
	PCBs	Q_1 * 3.28E-06	0	Q_3 * 3.28E-06	Q_4 * 1.73E-07	Q_4 * 3.45E-06	0.00064	0.0200
TN08010100001_2000	Chlordane	Q_1 * 4.15E-05	0	Q_3 * 4.15E-05	Q_4 * 2.18E-06	Q_4 * 4.32E-05	0.0080	0.1134
	Dioxins	Q_1 * 5.12E-09	0	Q_3 * 5.12E-09	Q_4 * 2.70E-10	Q_4 * 5.39E-09	1.0E-06	5.0E-06
	PCBs	Q_1 * 3.28E-06	0	Q_3 * 3.28E-06	Q_4 * 1.73E-07	Q_4 * 3.45E-06	0.00064	0.0198
TN08010100001_3000	Chlordane	Q_1 * 4.15E-05	0	Q_3 * 4.15E-05	Q_4 * 2.18E-06	Q_4 * 4.32E-05	0.0080	0.1134
	Dioxins	Q_1 * 5.12E-09	0	Q_3 * 5.12E-09	Q_4 * 2.70E-10	Q_4 * 5.39E-09	1.0E-06	5.0E-06
	PCBs	Q_1 * 3.28E-06	0	Q_3 * 3.28E-06	Q_4 * 1.73E-07	Q_4 * 3.45E-06	0.00064	0.0198
TN08010100001_4000	Chlordane	Q_1 * 4.15E-05	0	Q_3 * 4.15E-05	Q_4 * 2.18E-06	Q_4 * 4.32E-05	0.0080	0.1134
	Dioxins	Q_1 * 5.12E-09	0	Q_3 * 5.12E-09	Q_4 * 2.70E-10	Q_4 * 5.39E-09	1.0E-06	5.0E-06
	PCBs	Q_1 * 3.28E-06	0	Q_3 * 3.28E-06	Q_4 * 1.73E-07	Q_4 * 3.45E-06	0.00064	0.0198
TN08010100001_5000	Chlordane	Q_1 * 4.15E-05	0	Q_3 * 4.15E-05	Q_4 * 2.18E-06	Q_4 * 4.32E-05	0.0080	0.1134
	Dioxins	Q_1 * 5.12E-09	0	Q_3 * 5.12E-09	Q_4 * 2.70E-10	Q_4 * 5.39E-09	1.0E-06	5.0E-06
	PCBs	Q_1 * 3.28E-06	0	Q_3 * 3.28E-06	Q_4 * 1.73E-07	Q_4 * 3.45E-06	0.00064	0.0198

1 In order for the Mississippi River within the State of Tennessee to attain water quality standards, such standards will need to be met at the Tennessee border. Consistent with EPA guidance, this TMDL identifies the allowable loads from upstream and adjoining states at the Tennessee border that are necessary to attain Tennessee water quality standards for chlordane, dioxins, and PCBs. This lumped allocation to the other states is expressed as a function of flow (Q_1), where Q_1 represents the sum of flows (in terms of cfs as an annual average) from Kentucky, Missouri, and Arkansas that enter the Mississippi River at the Tennessee border. For example, if the total annual average flows from other states were determined to be 100,000 cfs, the associated allocation for chlordane is 4.15 lbs/day.

2 The WLA is specific to point sources within Tennessee that discharge directly to the Mississippi River. Future discharges from point sources would be evaluated on a case-by-case basis, and could be allowed as long as the applicable criteria are met at the end-of-pipe.

3 The LA is specific to nonpoint sources within Tennessee that drain to the Mississippi River. The LA is expressed as a function of flow (Q_3), where Q_3 represents the sum of flows (in terms of cfs as an annual average) of waters within Tennessee that drain to the Mississippi River. For example, if the annual average flow from the Forked Deer River was determined to be 1,000 cfs, the associated allocation for chlordane is 4.152E-02 lbs/day.

4 The TMDL is expressed as a function of flow (Q_4) where Q_4 is in terms of cubic feet per second as an annual average and represents the sum of Q_1 and Q_3 (e.g., $Q_1 + Q_3 = Q_4$).

5 The TMDL is also expressed in terms of maximum allowable water column concentration and maximum fish tissue concentration because TDEC recognizes that these values provide information that potentially will be more useful regarding TMDL implementation efforts than the values that are expressed in terms of an allowable load.

6 Daily load, in lbs/day, is expressed as an annual average.

TOTAL MAXIMUM DAILY LOADS (TMDLs) FOR CHLORDANE, DIOXIN AND PCBs IN THE MISSISSIPPI RIVER MISSISSIPPI RIVER WATERSHED (HUC 08010100)

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries for which technology-based effluent limitations are not stringent enough to protect any water quality standard applicable to such waters. Impaired waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those waterbodies that are not attaining water quality standards. State water quality standards consist of designated use(s) for individual waterbodies, appropriate numeric and narrative water quality criteria protective of the designated uses, and an antidegradation statement. The TMDL process establishes the maximum allowable loadings of pollutants for a waterbody that will allow the waterbody to maintain water quality standards. The TMDL may then be used to develop controls for reducing pollution from both point and non-point sources in order to restore and maintain the quality of water resources (USEPA, 1991).

2.0 SCOPE OF DOCUMENT

The Mississippi River is 2,320 miles long, beginning at Lake Itasca in Minnesota and ending at the Gulf of Mexico. The Mississippi River drains nearly 41% of the continental U.S. and flows thru or forms the boundary of 10 states, including Tennessee. This document presents details of TMDL development for waterbodies in the Mississippi River Watershed, identified on Tennessee's 2006 303(d) list as not supporting designated uses due, in part, to elevated levels of these pollutants in the fish tissue. This document addresses only the main stem of the Mississippi River and potential sources in Tennessee. McKellar Lake, segment TN08010100001_1100, will be addressed in a separate TMDL.

It should be noted that the segments addressed in this TMDL form the boundary between Tennessee and the states of Arkansas and Missouri. As such, these segments could be impacted by potential sources in either Arkansas or Missouri, as well as by potential sources upstream of the Tennessee/Kentucky border.

3.0 WATERSHED DESCRIPTION

The Mississippi River Watershed, Hydrologic Unit Code (HUC) 08010100, is located in the western part of Tennessee (ref.: Figure 1). The information (including figures and tables) presented hereafter in this document is for the Tennessee portion of the watershed only. The Mississippi River Watershed includes parts of Dyer, Lake, Lauderdale, Shelby and Tipton counties in Tennessee.

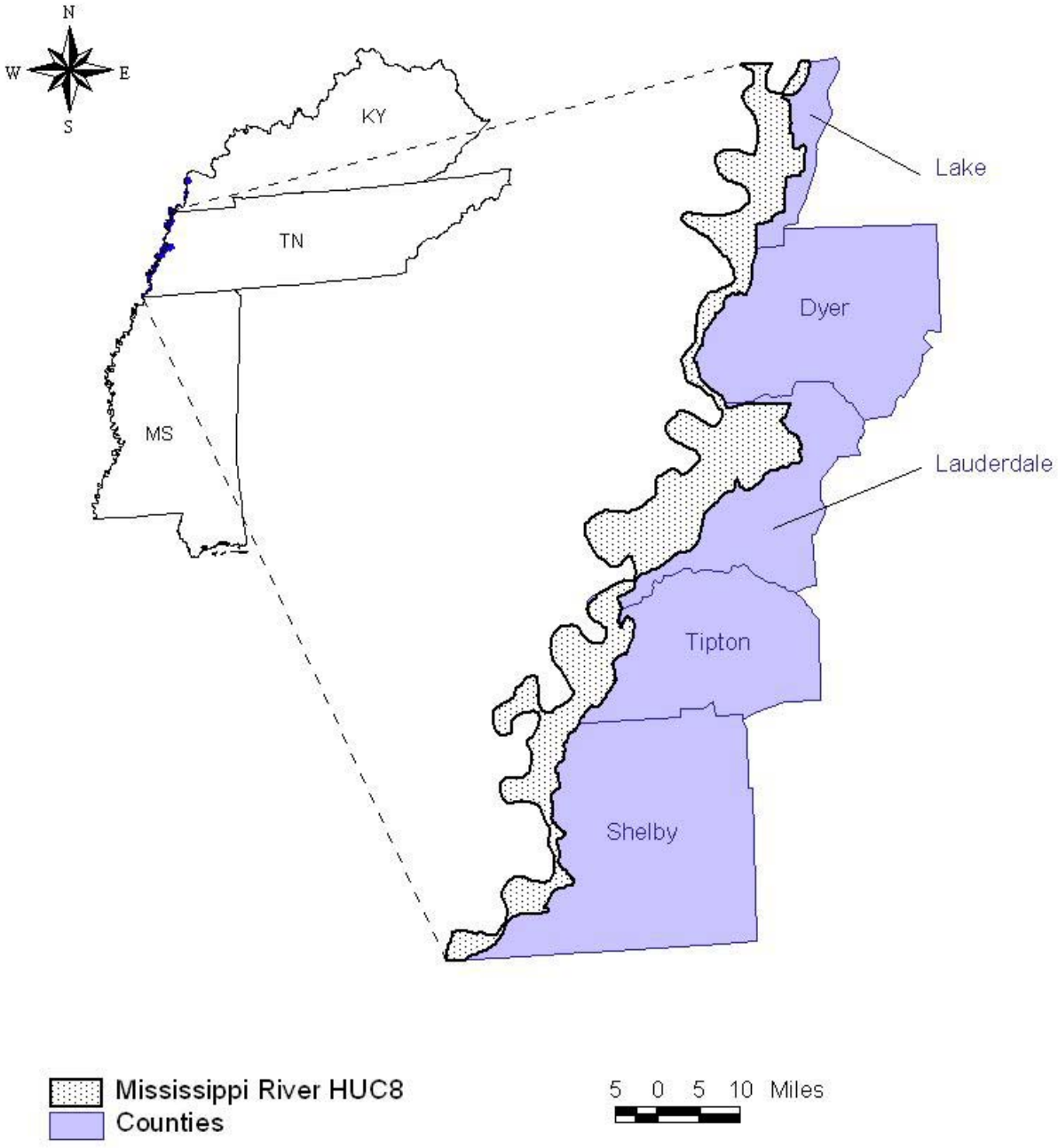

Figure 1 Location of the Mississippi River Watershed

The Tennessee portion of the Mississippi River watershed lies within two Level III ecoregions (Mississippi Alluvial Plain and Mississippi Valley Loess Plains) and contains five Level IV subecoregions as shown in Figure 2:

- The **Northern Holocene Meander Belts (73a)** within Tennessee is a relatively flat region of Quaternary alluvial deposits of sand, silt, clay, and gravel. It is bounded distinctly on the east by the Bluff Hills (74a), and on the west by the Mississippi River. Average elevations are 200-300 feet with little relief. Most of the region is in cropland, with some areas of deciduous forest. Soybeans, cotton, corn, sorghum, and vegetables are the main crops. The natural vegetation consists of Southern floodplain forest (oak, tupelo, bald cypress). The two main distinctions in the Tennessee portion of the ecoregion are between areas of loamy, silty, and sandy soils with better drainage, and areas of more clayey soils of poor drainage that may contain wooded swamp-land and oxbow lakes. Waterfowl, raptors, and migratory songbirds are relatively abundant in the region.
- The **Northern Pleistocene Valley Trains (73b)** within Tennessee is a flat to irregular alluvial plain composed of sandy to gravelly glacial outwash overlain by alluvium; sand sheets, widespread in the St. Francis Lowlands (73c) are absent. The Pleistocene outwash deposits of Ecoregion 73b are usually coarser and better drained than the alluvial deposits of Ecoregions 73a, 73d, and 73f. They were transported by the Mississippi River and its tributaries and have been subsequently eroded, reduced in size, and fragmented by laterally migrating channels or buried by thick sediments. Ecoregion 73b has little local relief or stream incision. Elevations tend to be slightly higher than adjacent parts of Ecoregions 73a and 73d. Cropland is extensive and has largely replaced the original forests; soybeans are the main crop and cotton is also produced. The few remaining forests are dominated by species typical of higher bottomlands such as Nuttall oak, willow oak, swamp chestnut oak, sugarberry, and green ash. There are more lowland oaks in Ecoregion 73b than in Ecoregions 73a and 73d.
- The **Northern Backswamps (73d)** within Tennessee is made up of low-lying overflow areas on floodplains, and includes poorly-drained flats and swales. Water often collects in its marshes, swamps, oxbow lakes, ponds, and low gradient streams. Soils developed from clayey alluvium including overbank and slack-water deposits; they commonly have a high shrink-swell potential and are locally rich in organic material. Water levels are seasonally variable. Native vegetation in the wettest areas is generally dominated by bald cypress—water tupelo forest; slightly higher and better drained sites have overcup oak—water hickory forest and the highest, best-drained areas support Nuttall oak forest. Today, bottomland forest, cropland, farmed wetlands, pastureland, and catfish farms occur. Backswamps are important areas for capturing excess nutrients from local waters and for storing water during heavy rain events.
- The **Bluff Hills (74a)** consist of sand, clay, silt, and lignite, and are capped by loess greater than 60 feet deep. The disjunct region in Tennessee encompasses those thick loess areas that are generally the steepest, most dissected, and forested. The carved loess has a mosaic of microenvironments, including dry slopes and ridges, moist slopes, ravines, bottomland areas, and small cypress swamps. While oak-hickory is the general forest type, some of the undisturbed bluff vegetation is rich in

mesophytes, such as beech and sugar maple, with similarities to hardwood forests of eastern Tennessee. Smaller streams of the Bluff Hills have localized reaches of increased gradient and small areas of gravel substrate that create aquatic habitats that are distinct from those of the Loess Plains (74b) to the east. Unique, isolated fish assemblages more typical of upland habitats can be found in these stream reaches. Gravels are also exposed in places at the base of the bluffs.

- The **Loess Plains (74b)** are gently rolling, irregular plains, 250-500 feet in elevation, with loess up to 50 feet thick. The region is a productive agricultural area of soybeans, cotton, corn, milo, and sorghum crops, along with livestock and poultry. Soil erosion can be a problem on the steeper, upland Alfisol soils; bottom soils are mostly silty Entisols. Oak-hickory and southern floodplain forests are the natural vegetation types, although most of the forest cover has been removed for cropland. Some less-disturbed bottomland forest and cypress-gum swamp habitats still remain. Several large river systems with wide floodplains, the Obion, Forked Deer, Hatchie, Loosahatchie, and Wolf, cross the region. Streams are low-gradient and murky with silt and sand bottoms, and most have been channelized.

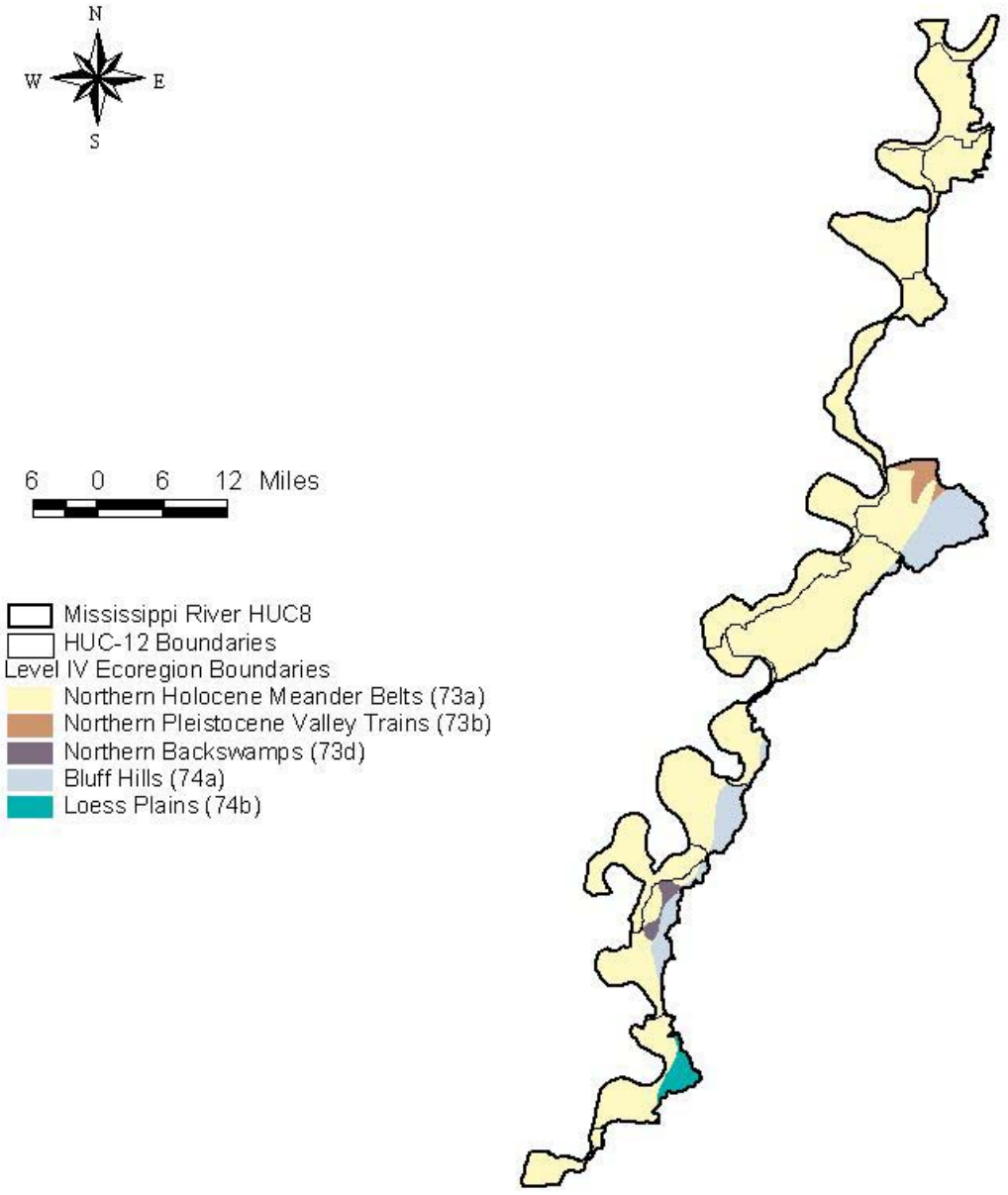

Figure 2 Level IV Ecoregions in the Mississippi River Watershed

The Tennessee portion of the Mississippi River Watershed has approximately 515.9 miles of streams and 125 reservoir/lake acres (TDEC, 2006). The Tennessee portion of the Mississippi River Watershed drains approximately 583 square miles into the Mississippi River. Watershed land use distribution is based on the Multi-Resolution Land Characteristic (MRLC) databases derived from Landsat Thematic Mapper digital images from the period 1990-1993. Although changes in the land use of the Mississippi River Watershed have occurred since 1993 as a result of development, this is the most current land use data available. Table 1 summarizes land use for the Mississippi River Watershed as shown in Figure 3.

Table 1 Land Use Distribution – Mississippi River Watershed

Land Use	**Area**		**% of watershed**
	acres	**mi^2**	
Bare Rock/Sand Clay	534	0.83	0.1
Deciduous Forest	27,453	42.88	7.4
Emergent Herbaceous Wetlands	818	1.28	0.2
Evergreen Forest	941	1.47	0.3
High Intensity Commercial/Industrial/Transportation	2,693	4.21	0.7
High Intensity Residential	2,521	3.94	0.7
Low Intensity Residential	2,666	4.16	0.7
Mixed Forest	9,343	14.59	2.5
Open Water	71,965	112.41	19.3
Other Grasses (Urban/recreational; e.g. parks, lawns)	1,458	2.28	0.4
Pasture/Hay	9,554	14.92	2.6
Quarries/Strip Mines/Gravel Pits	42	0.07	0.0
Row Crops	141,408	220.88	37.9
Transitional	485	0.76	0.1
Woody Wetlands	101,512	158.56	27.2
Total	**373,392**	**583.24**	**100.0**

Note: A spreadsheet was used for this calculation and values are approximate due to rounding.

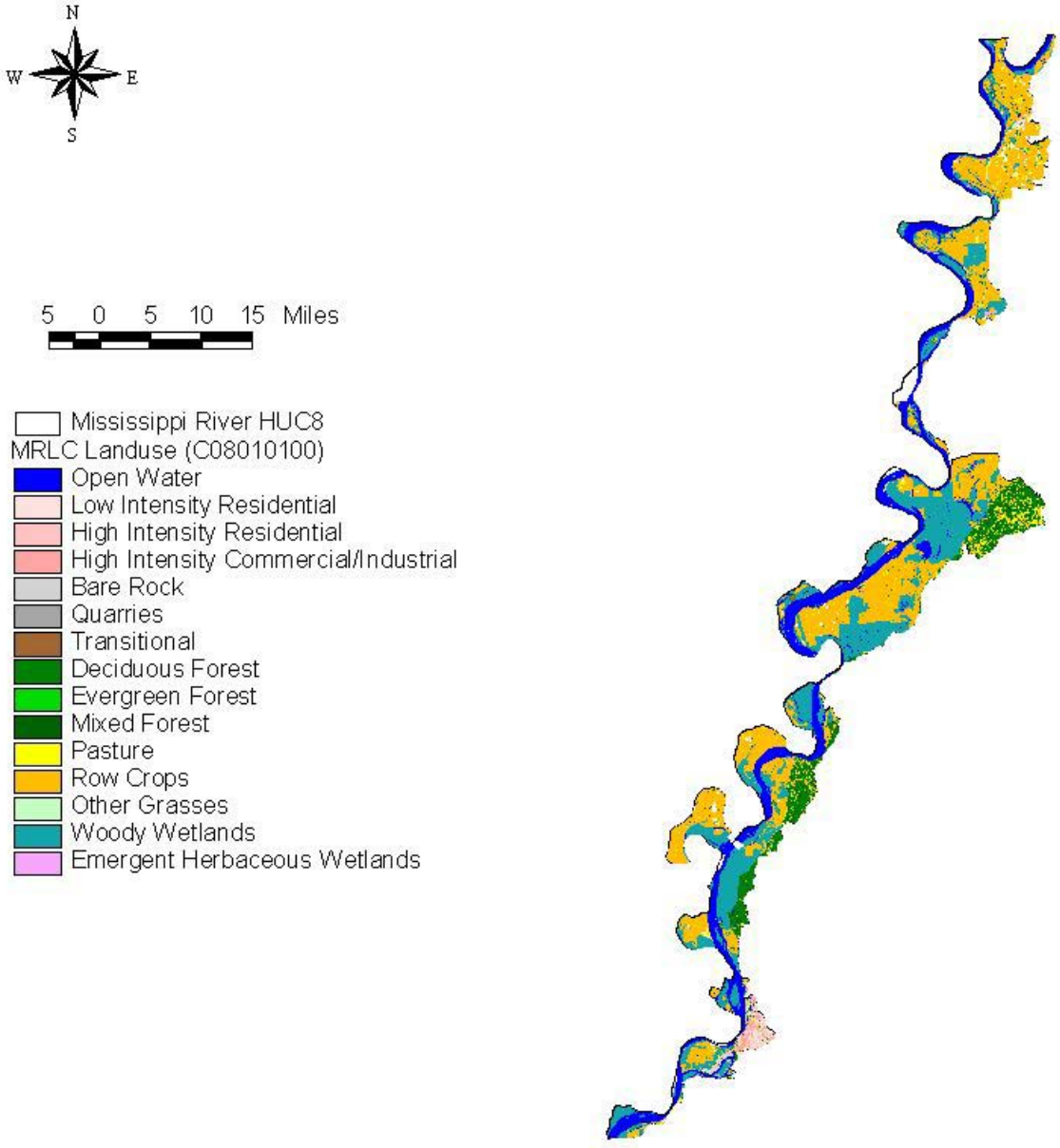

Figure 3 Land Use in the Mississippi River Watershed

4.0 PROBLEM DEFINITION

The State of Tennessee's final 2006 303(d) list (TDEC, 2006a) was approved by the U.S. Environmental Protection Agency (EPA), Region IV in October of 2006. The list identified five segments of the Mississippi River in the Mississippi River Watershed as not fully supporting designated use classifications due, in part, to elevated levels of chlordane, dioxins, and polychlorinated biphenyls (PCBs) in fish tissue samples. An excerpt from the *2006 303(d) List* is presented in Table 2. For the sake of brevity, future references to specific impaired segments will be by the last 4 digits of the waterbody ID. Impaired segments of the Mississippi River are shown in Figure 4. Note that there is also a fishing advisory for the Mississippi River from the Mississippi state line to just downstream of Meeman-Shelby State Park (approximately 31 miles) (TDEC, 2004).

The designated use classifications for the Mississippi River include fish & aquatic life, industrial water supply, irrigation, livestock watering & wildlife, navigation, and recreation. All segments except segment 1000 are also designated for domestic water supply.

All segments of the Mississippi River in Tennessee have been classified as high quality waters due to the presence of the Federal endangered Pallid Sturgeon and the State threatened Blue Sucker.

4.1 Chlordane

The term chlordane refers to a mixture of stereoisomers primarily in the cis (alpha) and trans (gamma) forms. Technical grade chlordane, on the other hand, is a mixture of various chlorinated hydrocarbons (e.g. heptachlor, chlordene, and nonachlor) in addition to the cis and trans isomers. Chlordane was widely used in the United States as an insecticide for agricultural crops and livestock, for lawns and gardens, and also for underground treatment around the foundation of homes (USEPA, 1997). Due to rising concerns over the product's safety, however, the U.S. Environmental Protection Agency began to restrict the use of chlordane on food crops, lawns, and gardens as early as 1978.

Chlordane is an environmentally persistent and bioaccumulative substance, which has been classified as a probable human carcinogen. The Environmental Protection Agency canceled all chlordane uses in 1988 except its use for fire ant control in power transformers. Chlordane still can be manufactured in the United States, but it can only be sold to or used by foreign countries. According to *Toxicological Review of Chlordane* (USEPA, 1997a), "[Chlordane] residues still exist in soils and sediments and chlordane bioaccumulates in fatty tissue of fish and humans; this bioaccumulation is a source of current concern." Chlordane has the potential to damage liver, kidneys, heart, lungs, spleen and adrenal glands as well as being a potential to cause cancer.

Table 2 Final 2006 303(d) List for Stream Impairment Due to Chlordane, Dioxins and PCBs

Waterbody ID	Impacted Waterbody	River Miles Impaired	Cause (Pollutant)	Pollutant Source
TN08010100001_1000 From Mississippi stateline to confluence of Loosahatchie River	Mississippi River	24.9	PCBs Dioxin Chlordane Nitrate Loss of biological integrity due to siltation Other Habitat Alterations	Agriculture Discharges from MS4 Area Dredging Contaminated Sediment Sources Outside the State
TN08010100001_2000 From confluence of Loosahatchie River to confluence of Hatchie River	Mississippi River	40.0	PCBs Dioxin Chlordane Nitrate Loss of biological integrity due to siltation Other Habitat Alterations	Agriculture Dredging Contaminated Sediment Sources from Other States
TN08010100001_3000 From confluence of Hatchie River to confluence of Obion River	Mississippi River	45.2	PCBs Dioxin Chlordane Nitrate Loss of biological integrity due to siltation Other Habitat Alterations	Agriculture Dredging Contaminated Sediment Sources from Other States
TN08010100001_4000 From Confluence of Obion River to Kentucky stateline (d/s of Bessie Bend)	Mississippi River	74.0	PCBs Dioxin Chlordane Nitrate Loss of biological integrity due to siltation Other Habitat Alterations	Agriculture Dredging Contaminated Sediment Sources from Other States
TN08010100001_5000 From Kentucky stateline (d/s of Bessie Bend) to Kentucky stateline (u/s of Bend)	Mississippi River	10.2	PCBs Dioxin Chlordane Nitrate Loss of biological integrity due to siltation Other Habitat Alterations	Agriculture Dredging Contaminated Sediment Sources from Other States

Note: There is a fishing advisory on the Mississippi River from the Mississippi Stateline to just downstream of Meeman-Shelby State Park (31 miles).

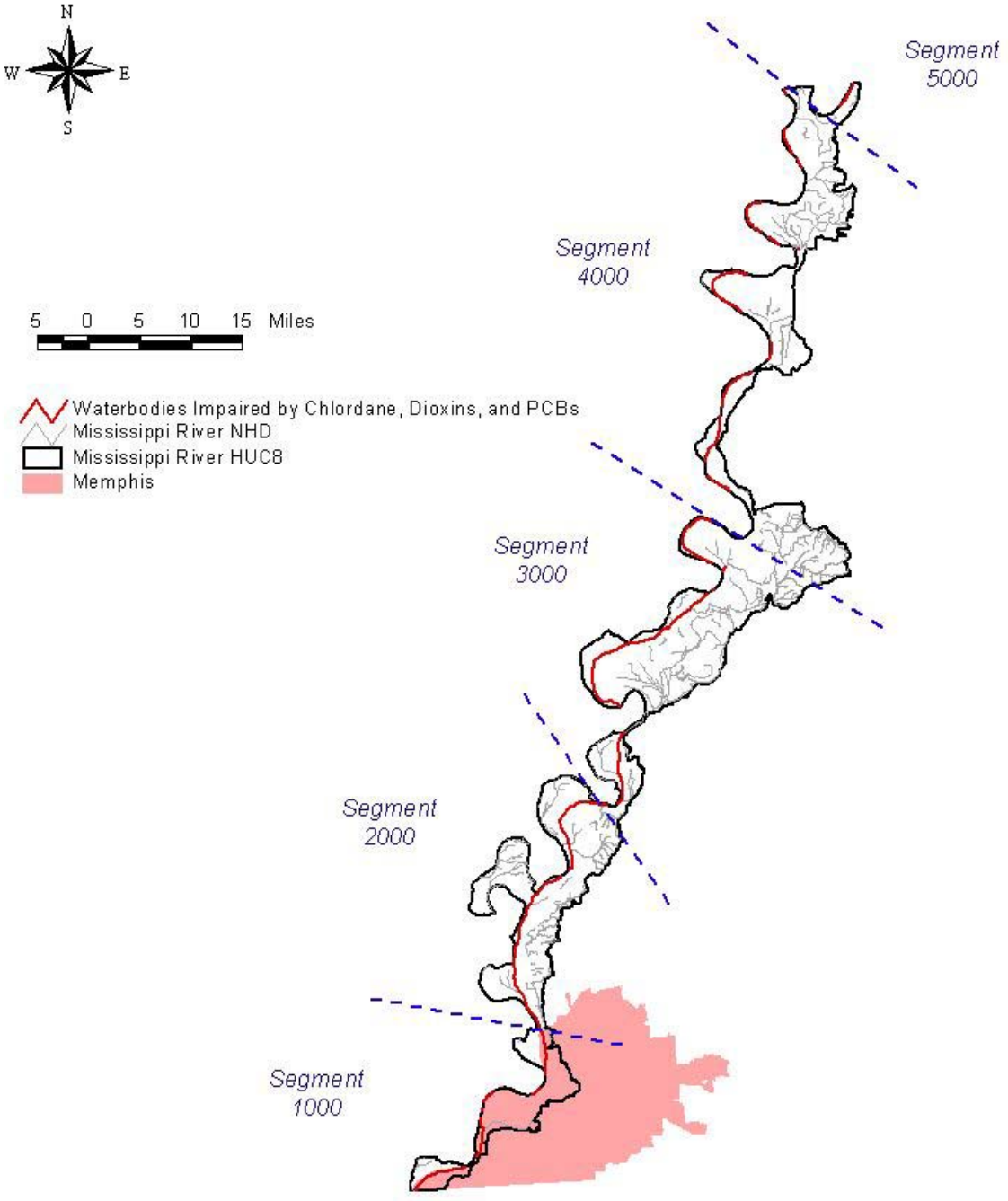

Figure 4 Location of the Mississippi River Chlordane, Dioxins and PCB Impairments (as documented on the Final *2006 303(d) List*)

4.2 Dioxins

Dioxins are a group of 210 synthetic chlorinated dibenzofuran (CDF) and dibenzo-p-dioxin (CDD) species. Some polychlorinated biphenyls (PCBs) are also regarded as "dioxin-like" in nature. Each congener possesses different physical and chemical properties. As a result, there is a range of toxicity among these structurally related organics. 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) is the most toxic of any dioxins. In fact, Toxic Equivalent Factors (TEFs) were derived to express the toxicity of other dioxins "as a fraction of the toxicity attributed to 2,3,7,8-TCDD" (ATSDR, 1998).

Dioxins were largely created as unintentional "by-products of incineration and combustion processes, chlorine bleaching in pulp and paper mills, and as contaminants in certain chlorinated organic chemicals" (USEPA, 1999a). These chlorinated hydrocarbons are highly persistent environmental contaminants, often residing in the soil and sediments. According to *An Inventory of Sources and Environmental Releases of Dioxin-Like Compounds in the United States for the Years 1987, 1995, and 2000*, "dioxin-like compounds enter surface water from atmospheric deposition, stormwater runoff erosion, and discharges of anthropogenic wastes" (USEPA, 2006).

Humans are predominately exposed to dioxins through dietary intake. Dioxins have been demonstrated to bioaccumulate in the aquatic food chain; therefore, contaminated fish and shellfish are a primary route of exposure. The exposure to any dioxins is associated with a number of adverse effects. The U.S. Environmental Protection Agency considers dioxins as probable human carcinogens. Furthermore, experiments "have shown toxic effects to the liver, gastrointestinal system, blood, skin, endocrine system, immune system, nervous system, and reproductive system" (USEPA, 1999a).

4.3 Polychlorinated Biphenyls (PCBs)

There are approximately 209 congeners of polychlorinated biphenyls. These 209 synthetic organic compounds vary not only in their physical properties, but also in their toxicity (USEPA,1999). PCBs were sold as a mixture that was based upon the percentage of chlorination. Aroclor 1248, 1254, and 1260 indicate the relative percentages 48, 54, 60 percent respectively of chlorination contained in each of these mixtures.

PCBs were manufactured in the United States from the 1920's until 1979 when they were banned by the U.S. Environmental Protection Agency. Prior to this ban, PCBs were commonly used in transformers, capacitors, coatings, adhesives, and an assortment of other products. The manufacturing ban on PCBs did not require all PCB-containing materials to be removed from use. Therefore, some PCBs may still be utilized commercially. Before strict disposal regulations were established, large amounts of PCBs were discarded improperly. So, although the production of PCBs has ceased, these chemicals are widely distributed throughout the environment.

As stated in *Fact Sheet: Polychlorinated Biphenyls Update: Impact on Fish Advisories* (USEPA, 1999):

> Currently, the major source of PCBs is environmental reservoirs from past releases. PCBs have been detected in soil, surface water, air, sediment, plants, and animal tissue in all regions of the earth. PCBs are highly persistent in the

environment with reported half-lives in soil and sediment ranging from months to years.

Once in the sediment, PCBs can enter the aquatic food chain. PCBs are fat-soluble chemicals with the potential to concentrate in fish tissue. As a result, humans may be exposed to PCBs through the consumption of contaminated foods, primarily contaminated fish. Studies have demonstrated adverse health effects resulting from PCB exposure. PCBs are classified as probable human carcinogens and among other things have been shown to be toxic to the immune system, the reproductive system, the nervous system, and the endocrine system.

5.0 TARGET IDENTIFICATION

In order for a TMDL to be established, a numeric "target" protective of the uses of the water must be identified to serve as the basis for the TMDL. Fish tissue target criteria will be used in this TMDL because, in the State of Tennessee, assessment of waterbody segments for impairment due to chlordane, dioxins, and PCBs is based on fish tissue concentration. A detailed discussion of the calculations involved in the development of fish tissue target criteria, and the relationship of fish tissue concentrations to published numerical water column criteria, is included in Appendix A. For the purpose of this TMDL, target criteria will be expressed as the fish tissue concentrations summarized in Table 3. These values are based on the water quality criteria for the recreation designated use classification. The value given for "organism only" will apply to segment 1000 because it is not designated for domestic water supply. The value given for "water & organisms" will apply to the remaining four segments.

Table 3. Fish Tissue Target Criteria

Pollutant	Organism only	Water & Organisms
	(mg/kg)	(mg/kg)
Chlordane	0.1142	0.1134
Dioxins	5.0×10^{-6}	5.0×10^{-6}
PCB	0.0200	0.0198

6.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM TARGET

Fish tissue samples were collected and analyzed as defined in *The Results of Fish Tissue Monitoring in Tennessee 1992-1997* (TDEC). Fish tissue data were available from six sampling sites along the Mississippi River:

- MISSI724.6SH – Mississippi River, under TVA power line, d/s Memphis South STP
- MISSI735.0SH – Mississippi River, Near I-40
- MISSI754.0SH – Mississippi River, near Meeman-Shelby State Park
- MISSI786.0LE – Mississippi River, near Osceola
- MISSI817.8LE – Mississippi River, near Blytheville
- MISSI873.5LA – Mississippi River, near Tiptonville

The location of these monitoring stations is shown in Figure 5. Fish tissue monitoring results for these stations are tabulated in Appendix B.

Note that the five segments of the Mississippi River are represented by six fish tissue monitoring stations. The monitoring stations at river miles 724.6 and 735.0 are located in segment 1000. The monitoring station at river mile 754.0 is located in segment 2000 and the monitoring station at river mile 786.0 is located in segment 3000. The monitoring stations at river miles 817.8 and 873.5 are located in segment 4000. There are no monitoring stations located in segment 5000.

Examination of the data shows exceedances of the fish tissue target criteria established in Section 5.0. Table 4 presents a summary of the fish tissue monitoring results for these stations compared to the fish tissue target criteria.

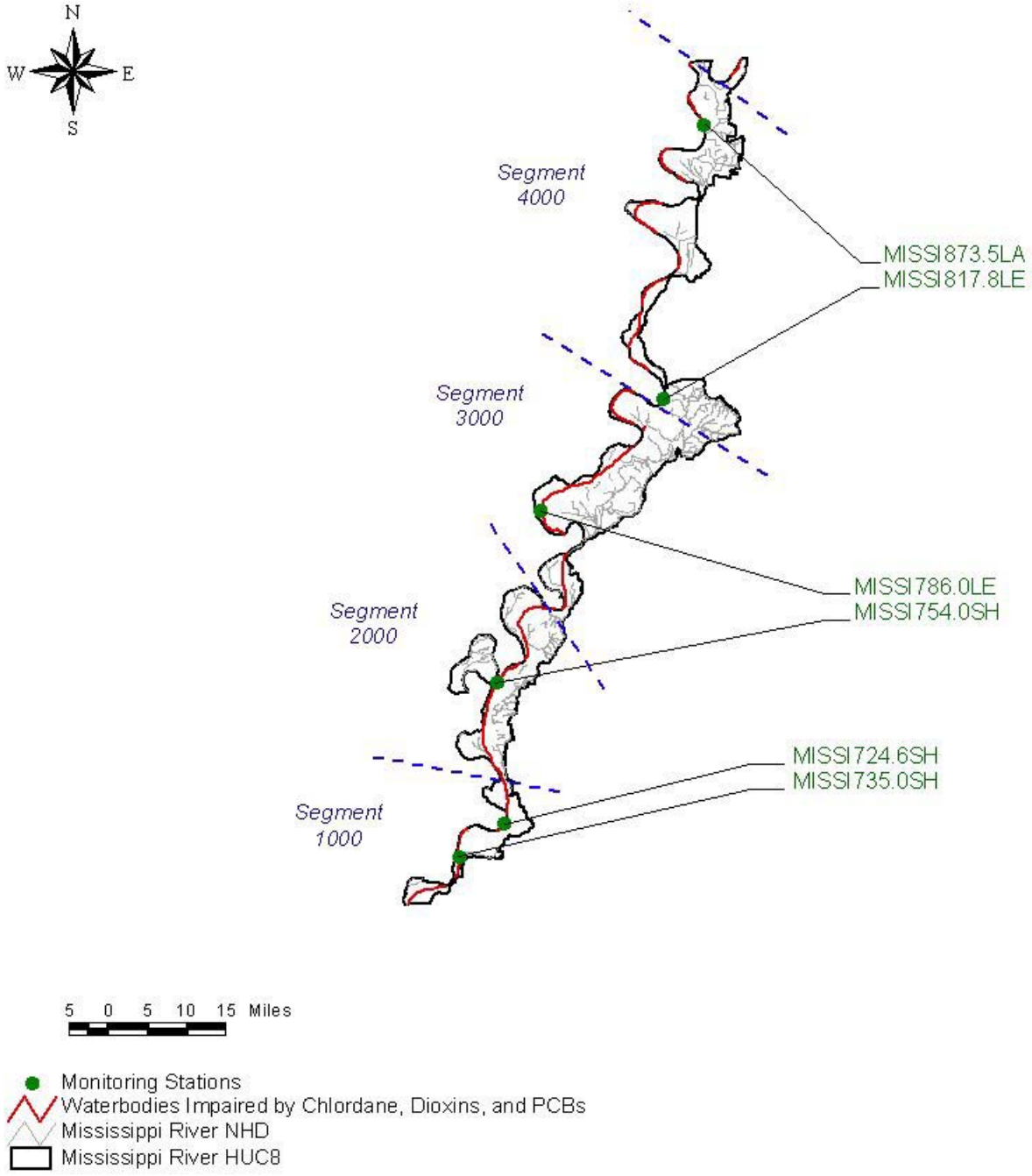

Figure 5 Sample Collection Sites along the Mississippi River

Table 4 Summary of TDEC Fish Tissue Monitoring Data

Monitoring Station	Date Range	Pollutant	Data Pts.	Target (mg/kg)	Min. (mg/kg)	Avg. (mg/kg)	Max. (mg/kg)	No. Exceed Target
MISSI724.6SH	1991 – 2006	Chlordane	31	0.1142[a]	0.0150	0.0736	0.4520	5
	1995 – 2006	Dioxins	15	$5x10^{-6}$	$9.00x10^{-8}$	$3.18x10^{-6}$	$1.47x10^{-5}$	3
	1991 – 2006	PCBs	31	0.0200[a]	0.0280	0.1699	0.5470	31
MISSI735.0SH	1991 – 2005	Chlordane	16	0.1142[a]	0.0055	0.0555	0.9630	6
	1990 – 2005	Dioxins	5	$5x10^{-6}$	$2.48x10^{-7}$	$7.74x10^{-7}$	$1.27x10^{-6}$	0
	1991 – 2005	PCBs	16	0.0200[a]	0.0340	0.1944	1.0200	16
MISSI754.0SH	1992 – 1997	Chlordane	26	0.1134	0.0090	0.0404	0.2950	1
	1995 – 1997	Dioxins	12	$5x10^{-6}$	$2.40x10^{-7}$	$2.80x10^{-6}$	$1.36x10^{-5}$	2
	1992 – 1997	PCBs	26	0.0198	0.018	0.1910	1.2900	25
MISSI786.0LE	1995 – 2005	Chlordane	19	0.1134	0.0066	0.0466	0.2990	2
	1995 – 2005	Dioxins	14	$5x10^{-6}$	$8.41x10^{-8}$	$1.53x10^{-6}$	$7.66x10^{-6}$	1
	1995 – 2005	PCBs	19	0.0198	0.010	0.4595	5.71	17
MISSI817.8LE	1995 – 2005	Chlordane	21	0.1134	0.0129	0.0374	0.1740	1
	1995 – 2005	Dioxins	16	$5x10^{-6}$	$1.65x10^{-7}$	$1.64x10^{-6}$	$5.8x10^{-6}$	1
	1995 – 2005	PCBs	21	0.0198	0.0340	0.1943	0.6630	21
MISSI873.5LA	1992 – 2005	Chlordane	26	0.1134	0.0062	0.0967	0.3250	8
	1992 – 2005	Dioxins	14	$5x10^{-6}$	$1.51x10^{-7}$	$1.81x10^{-6}$	$7.52x10^{-6}$	1
	1992 – 1996	PCBs	19	0.0198	0.0340	0.1942	0.7170	19

[a]Target for segment 1000 is based on “organism only” criteria.

7.0 SOURCE ASSESSMENT

An important part of the TMDL analysis is the identification of individual sources, source categories, or source subcategories of pollutants in the watershed and the amount of pollutant loading contributed by each of these sources. According to the Clean Water Act, sources are broadly classified as either point or non-point sources. Under 40 CFR §122.2, a point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. The National Pollutant Discharge Elimination System (NPDES) program regulates point source discharges. Regulated point sources include: 1) municipal and industrial wastewater treatment facilities (WWTFs); 2) storm water discharges associated with industrial activity (which includes construction activities); and 3) certain discharges from Municipal Separate Storm Sewer Systems (MS4s). For the purposes of these TMDLs, all sources of pollutant loading not regulated by NPDES are considered non-point sources.

7.1 Point Sources

There are numerous permitted dischargers in the Mississippi River Watershed. However, there are currently no permitted point source dischargers with existing allocations for chlordane, dioxins, or PCBs in the Tennessee portion of the Mississippi River Watershed.

There is one facility, Velsicol Chemical Corp., which is covered under the Tennessee Stormwater Multi-Sector General Permit (TNR051057) and is required to monitor for chlordane. The Velsicol facility is located in the Wolf River Watershed and discharges to Cypress Creek. The Wolf River is a tributary to the Mississippi River and drains into the Mississippi River Watershed. Discharges from and allocations for the Velsicol facility will be addressed in the Wolf River TMDL.

7.2 Non-point Sources

Assessments have determined that contaminated sediments and sources in other states are the most significant source of chlordane, dioxin, and PCB impairments in five segments of the Mississippi River. It should be noted that the segments addressed in this TMDL form the boundary between Tennessee and the states of Arkansas and Missouri. As such, these segments could be impacted by potential sources in either Arkansas or Missouri, as well as by potential sources upstream of the Tennessee/Kentucky border.

There are no Superfund sites located in the Mississippi River Watershed. However, several current or former sites listed on the NPL are located in watersheds that drain to the Mississippi River Watershed.

North Hollywood Dump (TND980558894) in Shelby County was identified as a hazardous waste site for chlordane. The North Hollywood Dump is located in the Wolf River Watershed. The Wolf River is a tributary of the Mississippi River. The site was used as a municipal dump from the 1930s until it was closed in 1967. During its operation industrial wastes from the former Hayden Chemical Company (which was purchased by Velsicol Chemical Corporation) were disposed of at this site. Velsicol Chemical Corporation, historically a major producer of chlordane, also disposed of industrial wastes at North Hollywood Dump – including "pesticide-contaminated sludge" (USEPA, 2007). The site was added to the NPL in 1983 (USEPA, 1983) and according to the U.S. EPA, pesticide-related compounds and heavy metals were detected on the site, with the soils and surface water being contaminated (USEPA, 1983). Later

investigations confirmed the presence of chlordane (and other contaminants) in the groundwater. Contaminated sediment was removed by dredging and drums were removed. The site was graded and a 2-foot clay cap was installed. Physical cleanup activities at the site have been completed and North Hollywood Dump was removed from the NPL in 1997. Groundwater samples indicate that the site has consistently met performance criteria. However, recreational activity has been restricted and "long term monitoring of groundwater, surface water, and fish will continue" because fish from an onsite pond were found to contain "pesticide levels exceeding cleanup goals" (USEPA, 2007)

The Memphis Defense Depot (TN4210020570) was identified as a hazardous waste site for PCBs. The Memphis Defense Depot is located in the Nonconnah River Watershed. The Nonconnah River is a tributary of the Mississippi River. The Memphis Defense Depot comprises 642 acres in south-central Memphis. The site consists of two adjacent sections: Dunn Field, an open storage and burial area of about 60 acres, and the Main Installation. The Depot has been in operation since 1942, providing material support to all U.S. military services. The Depot has conducted numerous operations utilizing hazardous substances with contamination resulting from leakage, spillage, disposal of out-of-date materials, and normal application of pesticides. Among the wastes disposed of at Dunn Field are oil, grease, paint thinners, methyl bromide, pesticides and cleaning fluids (chlorinated solvents). Ground water beneath and down-gradient of Dunn Field is contaminated with moderate to high concentrations of chlorinated solvents and relatively low concentrations of heavy metals. Removal actions beteween 1998 and 2001 excavated several areas of contaminated soil at the main installation. A barrier well system was constructed in 1998 and extended in 2001. Current data indicates that the barrier is preventing migration of contamination from the Depot property.

The Arlington Blending and Packaging site (TND980468557) was identified as a hazardous waste site for chlordane. The Arlington Blending and Packaging site is in the Loosahatchie Watershed which drains to the Mississippi River. From 1971 to 1978 the Arlington Blending & Packaging Company operated as a pesticide formulation and packaging facility. The company blended technical grade pesticides with solvents and emulsifiers. During the company's operation, spills and leakage of products occurred, resulting in soil, ditch sediment, and groundwater contamination. In 1996, excavation removed more than 95% of contamination identified in the soils. The second 5-year review in September 2007 concluded that the current remedy remains protective of human health and the environment.

These TMDLs will consider contaminated sediments in the Mississippi riverbed and sources in other states as the primary sources of chlordane, dioxins and PCBs in the Mississippi River. According to the U.S. Environmental Protection Agency, these pollutants have a very low solubility in water and low volatility and they are contained in sediments that serve as reservoirs from which these pollutants may be released over a long period of time (USEPA, 1999).

8.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOADS

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), non-point source loads (Load Allocations) and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$TMDL = \Sigma WLAs + \Sigma LAs + MOS$$

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure.

8.1 Critical Conditions and Seasonal Variation

Critical conditions were incorporated into the TMDL analysis by using the entire period of record (1991 - present) for the fish tissue monitoring data. Fish tissue data were collected during a variety of seasons. Chlordane, total dioxin, and PCB concentrations are not expected to fluctuate very much due to the fact that these pollutants are contained mainly in the sediment.

8.2 Margin of Safety

There are two methods for incorporating a Margin of Safety (MOS) in TMDL analysis: a) implicitly incorporate the MOS using conservative model assumptions to develop allocations; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. In these TMDLs, a 5% explicit MOS was incorporated to account for uncertainties.

8.3 Determination of TMDLs

In this document, the TMDLs are daily loads expressed as a function of the annual average flow (daily loading function). The daily load is calculated by multiplying the target water concentration by the annual average flow (represented by Q) and the required unit conversion factor.

Example – Target Concentration for PCBs = 0.00064 μg/L
Conversion Factor = 5.39×10^{-3} (lbs-L-sec/(μg-ft^3-day))
Daily Load = Q * 3.45×10^{-6} lbs/day

For implementation purposes, the TMDLs are also expressed as maximum water column concentrations and maximum fish tissue concentrations (as determined in Appendix A).

8.4 Determination of WLAs & LAs

There are currently no permitted point source dischargers with existing allocations for chlordane, dioxins or PCBs. Waste load allocations of zero are being provided.

The load allocation requires the contribution from non-point sources to be less than or equal to the TMDL target value. In the absence of point sources:

$$LA = TMDL - MOS$$

TMDLs, WLAs, and LAs are summarized in Table 5.

Table 5 TMDLs, WLAs, and LAs for the Mississippi River Watershed

Waterbody ID	Pollutant	Allocation to Other States[1]	WLAs[2]	LAs[3]	MOS	TMDLs[4]	Maximum H_2O Column Conc.[5]	Maximum Fish Tissue Conc.[5]
		(lbs/day)[6]	(lbs/day)[6]	(lbs/day)[6]	(lbs/day)[6]	(lbs/day)[6]	(μg/L)	(mg/kg)
TN08010100001_1000	Chlordane	Q_1 * 4.10E-05	0	Q_3 * 4.10E-05	Q_4 * 2.16E-06	Q_4 * 4.37E-05	0.0081	0.1142
	Dioxins	Q_1 * 5.12E-09	0	Q_3 * 5.12E-09	Q_4 * 2.70E-10	Q_4 * 5.39E-09	1.0E-06	5.0E-06
	PCBs	Q_1 * 3.28E-06	0	Q_3 * 3.28E-06	Q_4 * 1.73E-07	Q_4 * 3.45E-06	0.00064	0.0200
TN08010100001_2000	Chlordane	Q_1 * 4.15E-05	0	Q_3 * 4.15E-05	Q_4 * 2.18E-06	Q_4 * 4.32E-05	0.0080	0.1134
	Dioxins	Q_1 * 5.12E-09	0	Q_3 * 5.12E-09	Q_4 * 2.70E-10	Q_4 * 5.39E-09	1.0E-06	5.0E-06
	PCBs	Q_1 * 3.28E-06	0	Q_3 * 3.28E-06	Q_4 * 1.73E-07	Q_4 * 3.45E-06	0.00064	0.0198
TN08010100001_3000	Chlordane	Q_1 * 4.15E-05	0	Q_3 * 4.15E-05	Q_4 * 2.18E-06	Q_4 * 4.32E-05	0.0080	0.1134
	Dioxins	Q_1 * 5.12E-09	0	Q_3 * 5.12E-09	Q_4 * 2.70E-10	Q_4 * 5.39E-09	1.0E-06	5.0E-06
	PCBs	Q_1 * 3.28E-06	0	Q_3 * 3.28E-06	Q_4 * 1.73E-07	Q_4 * 3.45E-06	0.00064	0.0198
TN08010100001_4000	Chlordane	Q_1 * 4.15E-05	0	Q_3 * 4.15E-05	Q_4 * 2.18E-06	Q_4 * 4.32E-05	0.0080	0.1134
	Dioxins	Q_1 * 5.12E-09	0	Q_3 * 5.12E-09	Q_4 * 2.70E-10	Q_4 * 5.39E-09	1.0E-06	5.0E-06
	PCBs	Q_1 * 3.28E-06	0	Q_3 * 3.28E-06	Q_4 * 1.73E-07	Q_4 * 3.45E-06	0.00064	0.0198
TN08010100001_5000	Chlordane	Q_1 * 4.15E-05	0	Q_3 * 4.15E-05	Q_4 * 2.18E-06	Q_4 * 4.32E-05	0.0080	0.1134
	Dioxins	Q_1 * 5.12E-09	0	Q_3 * 5.12E-09	Q_4 * 2.70E-10	Q_4 * 5.39E-09	1.0E-06	5.0E-06
	PCBs	Q_1 * 3.28E-06	0	Q_3 * 3.28E-06	Q_4 * 1.73E-07	Q_4 * 3.45E-06	0.00064	0.0198

1 In order for the Mississippi River within the State of Tennessee to attain water quality standards, such standards will need to be met at the Tennessee border. Consistent with EPA guidance, this TMDL identifies the allowable loads from upstream and adjoining states at the Tennessee border that are necessary to attain Tennessee water quality standards for chlordane, dioxins, and PCBs. This lumped allocation to the other states is expressed as a function of flow (Q_1), where Q_1 represents the sum of flows (in terms of cfs as an annual average) from Kentucky, Missouri, and Arkansas that enter the Mississippi River at the Tennessee border. For example, if the total annual average flows from other states were determined to be 100,000 cfs, the associated allocation for chlordane is 4.15 lbs/day.

2 The WLA is specific to point sources within Tennessee that discharge directly to the Mississippi River. Future discharges from point sources would be evaluated on a case-by-case basis, and could be allowed as long as the applicable criteria are met at the end-of-pipe.

3 The LA is specific to nonpoint sources within Tennessee that drain to the Mississippi River. The LA is expressed as a function of flow (Q_3), where Q_3 represents the sum of flows (in terms of cfs as an annual average) of waters within Tennessee that drain to the Mississippi River. For example, if the annual average flow from the Forked Deer River was determined to be 1,000 cfs, the associated allocation for chlordane is 4.15E-02 lbs/day.

4 The TMDL is expressed as a function of flow (Q_4) where Q_4 is in terms of cubic feet per second as an annual average and represents the sum of Q_1 and Q_3 (e.g., $Q_1 + Q_3 = Q_4$).

5 The TMDL is also expressed in terms of maximum allowable water column concentration and maximum fish tissue concentration because TDEC recognizes that these values provide information that potentially will be more useful regarding TMDL implementation efforts than the values that are expressed in terms of an allowable load.

6 Daily load, in lbs/day, is expressed as an annual average.

9.0 IMPLEMENTATION PLAN

9.1 Point Sources

There are currently no NPDES permitted facilities in the Mississippi River Watershed with an existing allocation to discharge chlordane, dioxins, or PCBs to the Mississippi River.

9.2 Non-point Sources

The Tennessee Department of Environment & Conservation (TDEC) has no direct regulatory authority over most non-point source discharges. Voluntary, incentive-based mechanisms will be used to implement non-point source management measures in order to assure that measurable reductions in pollutant loadings can be achieved for the impaired waterbody.

Five segments of the Mississippi River were listed as impaired on the *2006 303(d) List* because they were not fully supporting designated use classifications due, in part, to elevated levels of chlordane, dioxins and PCBs. Contaminated sediment and sources in other states were identified as likely sources for chlordane, dioxin, and PCB contamination in the Mississippi River.

There are generally two options to prevent chlordane, dioxins, and PCBs contained in the sediment from being released to the river: 1) avoid disturbing the sediment or 2) remediate contaminated sites. TDEC recommends using option one whenever possible. If the sediment remains undisturbed, these pollutants should degrade over time. On the other hand, if the sediment in the riverbed must be disturbed, remediation efforts will be necessary to control the load of chlordane, dioxins, and PCBs in the river so that the water quality criteria are not exceeded. Strategies to identify sites with elevated levels of chlordane, dioxins, and PCBs may be helpful for implementing controls to prevent the contaminants from being released into the river. As less of the contaminants become biologically available the concentrations of chlordane, dioxins and PCBs measured in fish tissue samples should theoretically decline. Most importantly, continued fish tissue monitoring is advised to ensure that contamination decreases as time passes. This will help determine if additional loading is occurring.

Fish tissue data were examined to determine whether pollutant concentrations were decreasing over time. (See Appendix C.) Based on examination of data for the entire period of record, total chlordane and total dioxin concentrations may be decreasing. Total PCB concentrations did not appear to be decreasing. Insufficient data was available to determine whether a definite trend was present. Continued fish tissue monitoring is advised to determine whether contamination is decreasing as time passes.

9.3 Evaluation of TMDL Implementation Effectiveness

The effectiveness of these TMDLs will be assessed as data become available or when necessary. Watershed monitoring and assessment activities will provide information by which the effectiveness of chlordane, dioxin, and PCB load allocations can be evaluated. Continued fish tissue sampling will be necessary to monitor the efficacy of the proposed TMDLs. These results will be reevaluated during subsequent water quality assessment cycles as required by the Clean Water Act.

10.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, the proposed TMDLs for chlordane, dioxins and PCBs in the Mississippi River were placed on Public Notice for a 35-day period and comments were solicited. Steps taken in this regard include:

1) Notice of the proposed TMDLs was posted on the Tennessee Department of Environment and Conservation website. The notice invited public and stakeholder comments and provided a link to a downloadable version of the TMDL document.

2) Notice of the availability of the proposed TMDLs (similar to the website announcement) was included in one of the NPDES permit Public Notice mailings, which were sent to interested persons or groups who have requested this information.

3) A letter was sent to identified water quality partners in the Mississippi River Watershed advising them of the proposed chlordane, dioxins and PCB TMDLs and their availability on the TDEC website. The letter also stated that a written copy of the Draft TMDL document would be provided upon request. A letter was sent to the following partners:

Natural Resources Conservation Service
Tennessee Department of Agriculture
Tennessee Water Sentinels
United States Army Corps of Engineers
United States Fish and Wildlife Service
United States Geological Survey
Nature Conservancy

4) A draft copy of the proposed TMDLs was sent to the following MS4s:

TNS068276	Memphis Municipal Separate Storm Sewer System
TNS075663	Shelby County
TNS077585	Tennessee Department of Transportation

11.0 FURTHER INFORMATION

Further information concerning Tennessee's TMDL program can be found on the Internet at the Tennessee Department of Environment and Conservation website:

http://www.state.tn.us/environment/wpc/tmdl/

Technical questions regarding these TMDLs should be directed to the following members of the Division of Water Pollution Control staff:

Vicki S. Steed, P.E., Watershed Management Section
E-mail: Vicki.Steed@state.tn.us

Bruce Evans, P.E., Watershed Management Section
E-mail: Bruce.Evans@state.tn.us

Sherry H. Wang, Ph.D., Watershed Management Section
E-mail: Sherry.Wang@state.tn.us

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APPENDIX A

Development of Target Criteria For Chlordane, PCBs, and Dioxins

In the State of Tennessee, assessment of waterbody segments for impairment due to chlordane, dioxins, and PCBs is based on fish tissue concentration. Public fishing advisories are also considered based on fish tissue concentrations. Therefore, for the purpose of this TMDL, development of target criteria will be based on fish tissue concentration.

Chlordane and PCB Methodology

The formula for calculating the fish tissue concentration requiring a fish advisory is established by *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, October 2007* (TDEC, 2007). Section 1200-4-3-.03 (4) (l) is summarized below:

$$R = q * E \quad \text{(Equation A-1)}$$

where:

R = Plausible-upper-limit risk of cancer associated with a chemical in a fish species; in Tennessee, a risk level of 10^{-5} is used when considering a fish advisory
q = Carcinogenic Potency Factor for the specific chemical (kg-day/mg)
E = Exposure dose of the specific chemical (mg/kg-day) from the fish species

E is calculated based on the following formula:

$$E = C * I * X / W \quad \text{(Equation A-2)}$$

where:

C = Concentration of the chemical (mg/kg) in the edible portion of the fish species
I = Ingestion rate (g/day) of the fish species; 17.5 g/day will be used (USEPA, 2002)
X = Relative absorption coefficient; assumed to be 1.0
W = Average human mass (kg); 70 kg will be used (USEPA, 2002)

Combining equations A-1 and A-2 and solving for fish tissue concentration (C) results in the following equation:

$$C = (R * CF1 * W) / (q * I * X) \quad \text{(Equation A-3)}$$

where:

CF1 = Conversion Factor (1000 g/kg)

Once the fish tissue target concentration has been determined using Equation A-3, the corresponding water column concentration can be determined using the following equation:

$$C(water) = [C(fish) * CF2] / BCF \quad \text{(Equation A-4)}$$

where:

CF2 = Conversion Factor (1000 μg/mg)
BCF = Bioconcentration Factor (L/kg)

Using Equations A-3 and A-4 and published values for q and BCF, the target fish tissue concentrations were calculated for waterbodies not designated for drinking water supply (DWS):

Table A-1. Calculated Values for Waterbodies Not Designated for DWS

Pollutant	q	C (fish)	BCF	C (water)
	(kg-day/mg)	(mg/kg)	(L/kg)	(μg/L)
Chlordane	0.35	0.1142	14,100	0.0081
PCB	2.0	0.0200	31,200	0.00064

When addressing waterbodies designated for drinking water supply, the ingestion rate (I) must be adjusted to account for the combined intake of fish and water.

$$I2 = FI + WI \qquad \text{(Equation A-5)}$$

where:

FI = Fish Intake; 17.5 g/day will be used (USEPA, 2002)
WI = Water Intake, 2 L/day will be used (USEPA, 2002)

The water intake can be converted to an equivalent fish intake using information from Equation A-4:

$$WI = 2\ L/day * CF1 / BCF \qquad \text{(Equation A-6)}$$

Therefore:

$$I2 = 17.5 + (2 * CF1 / BCF) \qquad \text{(Equation A-7)}$$

Using Equations A-3 and A-4, published values for q and BCF, and substituting I2 for I, the target fish tissue concentrations for waterbodies designated for DWS were calculated:

Table A-2. Calculated Values for Waterbodies Designated for DWS

Pollutant	q	C (fish)	BCF	C (water)
	(kg-day/mg)	(mg/kg)	(L/kg)	(μg/L)
Chlordane	0.35	0.1134	14,100	0.0080
PCB	2.0	0.0198	31,200	0.000636

Comparison of the fish tissue concentrations in Tables A-1 and A-2 to the water quality criteria established in Section 1200-4-3-.03 (4) (j) for “Organisms Only” and “Water & Organisms” respectively confirms that the values are equivalent. The fish tissue concentrations in Tables A-1 and A-2 are also more stringent than the fish tissue concentrations calculated from the water column criteria established for the fish and aquatic life use classification. Therefore, the fish tissue concentrations in Tables A-1 and A-2 will be used as the target criteria for this TMDL.

Dioxin Methodology

For dioxin, a different methodology is used to determine water quality criterion and fish advisory level. The fish tissue concentration requiring a fish advisory is based on the water quality criterion as established by *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, October 2007* (TDEC, 2007). The water quality criterion is based on a combination of EPA and USFDA assumptions and was approved by EPA in 1999. (For a more complete explanation, see *Dioxin Levels in Pigeon River Fish: 1996-2002* [TDEC, 2002]). The water criterion of 1 ppq is multiplied by the bioconcentration factor for dioxin and the appropriate conversion factor:

$$C(fish) = [C(water) * BCF] / CF2 \qquad \text{(Equation A-8)}$$

where:

CF2 = Conversion Factor (1000 μg/mg)
BCF = Bioconcentration Factor (5,000 L/kg)

The resulting fish tissue concentration is:

$$C(fish) = [(1x10^{-6}\ \mu g/L) * (5000\ L/kg)] / (1000\ \mu g/mg) = 5x10^{-6}\ mg/kg$$

where:

$1\ ppq = 1x10^{-6}\ \mu g/L$

Therefore, the fish tissue concentration calculated from Equation A-8 ($5x10^{-6}$ mg/kg) will be used as the target criterion for this TMDL.

APPENDIX B

Fish Tissue Monitoring Data

There are several monitoring stations that provide fish tissue data for portions of the Mississippi River identified as impaired for chlordane, dioxins, and PCBs. The location of these monitoring stations is shown in Figure 5. Fish tissue data recorded at these stations are tabulated in Tables B-1 thru B-3.

In Table B-1, total chlordane was calculated as the sum of alpha chlordane, gamma chlordane, cis-nonachlor, and trans-nonachlor.

In Table B-2, total dioxins was calculated as the sum of the concentrations of all dioxin and dibenzofuran isomers after multiplication by the appropriate Toxic Equivalent Factor (TEF):

$$C_{dioxins} = \Sigma [C_i \times TEF_i]$$

where:

$C_{dioxins}$ = Total dioxins measured in fish tissue samples (ppt)
C_i = Concentration of isomer *i* in fish tissue samples (ppt)
TEF_i = Toxic Equivalent Factor specific for isomer

The TEF approach compares the relative toxicity of individual congeners to that of 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD), which is one of the most toxic and extensively studied of the dioxin and dioxin-like compounds. The TEF for 2,3,7,8-TCDD is defined as unity; and TEFs for all other chlorinated dibenzo-p-dioxin (CDD) congeners, chlorodibenzofurans (CDFs), and dioxin-like PCBs are less than one, thus reflecting their lower toxic potency. The use of TEFs allows the total dioxins to be expressed as a 2,3,7,8-TCDD toxic equivalent concentration for mixtures of CDDs, CDFs, and/or dioxin-like PCBs (ATSDR, 1998). The TEFs currently recommended by EPA are presented in Section 1200-4-3-.03 (4) (j) of the *State of Tennessee Water Quality Standards* (TDEC, 2007).

In Table B-3, PCB data presented is for Aroclor 1260. Aroclor 1260 will be used as a surrogate for total PCBs for TMDL analysis because it is considered to be one of the most toxic of the known Aroclor congeners due to its high chlorine content (60%) (ATSDR, 2000). Other Aroclors may have been present but were below detection limits.

Table B-1. Fish Tissue Monitoring Data for Chlordane

Monitoring Station ID	Date	Fish Species	Total Chlordane [mg/kg]
MISSI724.6SH	11/22/91	BLUE CATFISH	0.2030
	11/22/91	BLUE CATFISH	0.1190
	11/22/91	BLUE CATFISH	0.0680
	11/22/91	BLUE CATFISH	0.0840
	11/22/91	BLUE CATFISH	0.1270
	11/22/91	CHANNEL CATFISH	0.0610
	11/22/91	SMALLMOUTH BUFFALO	0.0990
	11/22/91	SMALLMOUTH BUFFALO	0.0740
	11/22/91	SMALLMOUTH BUFFALO	0.0150
	11/22/91	WHITE BASS	0.0315
	5/15/95	BLUE CATFISH	0.4520
	5/15/95	BLUE CATFISH	0.1130
	5/15/95	CARP	0.0570
	5/15/95	CARP	0.0380
	5/15/95	CARP	0.0230
	7/24/96	BLUE CATFISH	0.0450
	7/24/96	CARP	0.0260
	7/24/96	CHANNEL CATFISH	0.0450
	7/24/96	FLATHEAD CATFISH	0.0710
	7/24/96	LARGEMOUTH BASS	0.0190
	7/24/96	RIVER CARPSUCKER	0.0220
	7/24/96	STRIPED BASS	0.0370
	10/15/97	BLUE CATFISH	0.1630
	10/15/97	CARP	0.0400
	10/15/97	CHANNEL CATFISH	0.0610
	10/15/97	FLATHEAD CATFISH	0.0340
	10/15/97	SMALLMOUTH BUFFALO	0.0310
	10/15/97	WHITE BASS	0.0400
	11/9/06	BLUE CATFISH	0.0292
	11/9/06	CARPSUCKER	0.0292
	11/9/06	WHITE BASS	0.0262

Table B-1 (cont'd). Fish Tissue Monitoring Data for Chlordane

Monitoring Station ID	Date	Fish Species	Total Chlordane [mg/kg]
MISSI735.0SH	11/20/91	CARP	0.4320
	11/20/91	CARP	0.1350
	11/20/91	CARP	0.1770
	11/20/91	CARP	0.0740
	11/20/91	CARP	0.9630
	11/20/91	CHANNEL CATFISH	0.0830
	11/20/91	CHANNEL CATFISH	0.0460
	11/20/91	CHANNEL CATFISH	0.2330
	11/20/91	CHANNEL CATFISH	0.1100
	11/20/91	CHANNEL CATFISH	0.1240
	11/20/91	LARGEMOUTH BASS	0.0230
	11/20/91	WHITE CRAPPIE	0.0170
	9/7/05	BLUE CATFISH	0.0574
	9/7/05	BLUE CATFISH	0.0171
	9/7/05	SILVER CARP	0.0067
	9/7/05	WHITE BASS	0.0055
MISSI754.0SH	2/20/92	BIG MOUTH BUFFALO	0.0440
	2/20/92	BLUE CATFISH	0.0500
	2/20/92	BLUE CATFISH	0.0320
	2/20/92	BLUE CATFISH	0.0200
	2/20/92	SAUGER	0.0210
	2/20/92	SMALLMOUTH BUFFALO	0.0160
	2/20/92	SMALLMOUTH BUFFALO	0.0540
	2/20/92	WHITE BASS	0.0590
	5/16/95	BLUE CATFISH	0.0430
	5/16/95	CARP	0.0230
	5/16/95	CARP	0.0120
	5/16/95	LARGEMOUTH BASS	0.0260
	8/5/96	BLUE CATFISH	0.0190
	8/5/96	CARP	0.0170
	8/5/96	CHANNEL CATFISH	0.1120
	8/5/96	LARGEMOUTH BASS	0.0140
	8/5/96	LARGEMOUTH BASS	0.0120
	8/5/96	STRIPED BASS	0.0280
	8/8/96	RIVER CARP SUCKER	0.0240

Table B-1 (cont'd). Fish Tissue Monitoring Data for Chlordane

Monitoring Station ID	Date	Fish Species	Total Chlordane [mg/kg]
MISSI754.0SH (cont'd)	10/15/97	CARP	0.0240
	10/15/97	CHANNEL CATFISH	0.0170
	10/15/97	FLATHEAD CATFISH	0.0330
	10/15/97	LARGEMOUTH BASS	0.0090
	10/15/97	SMALLMOUTH BUFFALO	0.2950
	10/15/97	SMALLMOUTH BUFFALO	0.0160
	10/15/97	WHITE BASS	0.0300
MISSI786.0LE	5/17/95	BLUE CATFISH	0.0520
	5/17/95	CARP	0.0105
	5/17/95	CARP	0.0075
	5/17/95	SMALLMOUTH BUFFALO	0.0140
	8/5/96	CHANNEL CATFISH	0.0390
	8/5/96	CHANNEL CATFISH	0.1410
	8/6/96	CARP	0.0240
	8/6/96	CHANNEL CATFISH	0.2990
	8/6/96	LARGEMOUTH BASS	0.0120
	8/6/96	STRIPED BASS	0.0800
	10/14/97	BLUE CATFISH	0.0510
	10/14/97	CARP	0.0170
	10/14/97	CHANNEL CATFISH	0.0280
	10/14/97	SMALLMOUTH BUFFALO	0.0380
	10/14/97	WHITE BASS	0.0180
	9/7/05	CHANNEL CATFISH	0.0118
	9/7/05	CHANNEL CATFISH	0.0162
	9/7/05	SILVER CARP	0.0066
	9/7/05	WHITE BASS	0.0206
MISSI817.8LE	5/18/95	BLUE CATFISH	0.0370
	5/18/95	BLUE CATFISH	0.0165
	5/18/95	HYBRID BASS	0.0865
	5/18/95	SMALLMOUTH BUFFALO	0.0200
	5/18/95	SMALLMOUTH BUFFALO	0.0225
	8/7/96	CARP	0.0240
	8/7/96	CHANNEL CATFISH	0.0400
	8/7/96	LARGEMOUTH BASS	0.0140
	8/7/96	RIVER CARP SUCKER	0.0380
	8/7/96	STRIPED BASS	0.0310

Table B-1 (cont'd). Fish Tissue Monitoring Data for Chlordane

Monitoring Station ID	Date	Fish Species	Total Chlordane [mg/kg]
MISSI817.8LE (cont'd)	10/13/97	BLUE CATFISH	0.0330
	10/13/97	CARP	0.0260
	10/13/97	CHANNEL CATFISH	0.0270
	10/13/97	FLATHEAD CATFISH	0.1740
	10/13/97	SMALLMOUTH BUFFALO	0.0250
	10/13/97	WHITE BASS	0.0310
	9/7/05	CARP	0.0196
	9/7/05	CARP	0.0129
	9/7/05	CHANNEL CATFISH	0.0404
	9/7/05	CHANNEL CATFISH	0.0294
	9/7/05	WHITE BASS	0.0384
MISSI873.5LA	2/20/92	BIG MOUTH BUFFALO	0.1070
	2/20/92	BIG MOUTH BUFFALO	0.3250
	2/20/92	BLUE CATFISH	0.1920
	2/20/92	BLUE CATFISH	0.2390
	2/20/92	BLUE CATFISH	0.1040
	2/20/92	BLUE CATFISH	0.1030
	2/20/92	SMALLMOUTH BUFFALO	0.2720
	2/20/92	SMALLMOUTH BUFFALO	0.2800
	2/20/92	SMALLMOUTH BUFFALO	0.1240
	5/19/95	CARP	0.0080
	5/19/95	CHANNEL CATFISH	0.0330
	5/19/95	HYBRID BASS	0.0115
	8/8/96	CARP	0.0490
	8/8/96	CARP	0.0440
	8/8/96	CHANNEL CATFISH	0.0570
	8/8/96	LARGEMOUTH BASS	0.0190
	8/8/96	RIVER CARP SUCKER	0.0280
	8/8/96	STRIPED BASS	0.0280
	2/18/98	BLUE CATFISH	0.0410
	2/18/98	CARP	0.0210
	2/18/98	CHANNEL CATFISH	0.1160
	2/18/98	CHANNEL CATFISH	0.2220
	2/18/98	WHITE BASS	0.0470
	8/22/05	CARP	0.0264
	8/22/05	CHANNEL CATFISH	0.0062
	8/22/05	WHITE BASS	0.0114

Table B-2. Fish Tissue Monitoring Data for Dioxins

Monitoring Station ID	Date	Fish Species	Total Dioxins [ppt]
MISSI724.6SH	5/15/95	BLUE CATFISH	14.7300
	5/15/95	BLUE CATFISH	5.2100
	5/15/95	CARP	3.9900
	7/24/96	BLUE CATFISH	1.2800
	7/24/96	CHANNEL CATFISH	2.4700
	7/24/96	FLATHEAD CATFISH	0.6600
	10/15/97	BLUE CATFISH	6.4900
	10/15/97	CARP	2.5800
	10/15/97	CHANNEL CATFISH	2.8700
	10/15/97	FLATHEAD CATFISH	1.6800
	10/15/97	SMALLMOUTH BUFFALO	3.2500
	10/15/97	WHITE BASS	1.2300
	11/9/06	BLUE CATFISH	0.5200
	11/9/06	CARPSUCKER	0.6100
	11/9/06	WHITE BASS	0.0900
MISSI735.0SH	11/6/90	CHANNEL CATFISH	1.2000
	9/7/05	BLUE CATFISH	1.2704
	9/7/05	BLUE CATFISH	0.2479
	9/7/05	SILVER CARP	0.2706
	9/7/05	WHITE BASS	0.8803
MISSI754.0SH	5/16/95	BLUE CATFISH	13.6000
	5/16/95	CARP	5.3500
	8/5/96	BLUE CATFISH	0.3200
	8/5/96	CHANNEL CATFISH	4.0700
	8/5/96	LARGEMOUTH BASS	0.2400
	10/15/97	CARP	1.9900
	10/15/97	CHANNEL CATFISH	1.3800
	10/15/97	FLATHEAD CATFISH	0.7600
	10/15/97	LARGEMOUTH BASS	0.3400
	10/15/97	SMALLMOUTH BUFFALO	3.1200
	10/15/97	SMALLMOUTH BUFFALO	1.5100
	10/15/97	WHITE BASS	0.8700

Table B-2 (cont'd). Fish Tissue Monitoring Data for Dioxins

Monitoring Station ID	Date	Fish Species	Total Dioxins [ppt]
MISSI786.0LE	5/17/95	BLUE CATFISH	2.8400
	5/17/95	CARP	1.8100
	8/6/96	CARP	1.4600
	8/6/96	CHANNEL CATFISH	7.6600
	8/6/96	LARGEMOUTH BASS	0.2000
	10/14/97	BLUE CATFISH	0.9900
	10/14/97	CARP	1.3700
	10/14/97	CHANNEL CATFISH	2.0100
	10/14/97	SMALLMOUTH BUFFALO	1.0400
	10/14/97	WHITE BASS	1.0300
	9/7/05	CHANNEL CATFISH	0.1508
	9/7/05	CHANNEL CATFISH	0.1509
	9/7/05	SILVER CARP	0.0841
	9/7/05	WHITE BASS	0.6288
MISSI817.8LE	5/18/95	BLUE CATFISH	2.4700
	5/18/95	SMALLMOUTH BUFFALO	5.8300
	8/7/96	CARP	1.6100
	8/7/96	CHANNEL CATFISH	1.7100
	8/7/96	LARGEMOUTH BASS	0.4100
	10/13/97	BLUE CATFISH	1.8100
	10/13/97	CARP	2.2800
	10/13/97	CHANNEL CATFISH	1.5300
	10/13/97	FLATHEAD CATFISH	2.8100
	10/13/97	SMALLMOUTH BUFFALO	1.5300
	10/13/97	WHITE BASS	1.4200
	9/7/05	CARP	0.5928
	9/7/05	CARP	0.1645
	9/7/05	CHANNEL CATFISH	0.6064
	9/7/05	CHANNEL CATFISH	0.6561
	9/7/05	WHITE BASS	0.7628
MISSI873.5LA	2/20/92	BLUE CATFISH	2.2100
	5/19/95	CARP	1.2200
	5/19/95	CHANNEL CATFISH	7.5200

Table B-2 (cont'd). Fish Tissue Monitoring Data for Dioxins

Monitoring Station ID	Date	Fish Species	Total Dioxins [ppt]
MISSI873.5LA (cont'd)	8/8/96	CARP	2.2600
	8/8/96	CHANNEL CATFISH	1.9900
	8/8/96	LARGEMOUTH BASS	0.6100
	2/18/98	BLUE CATFISH	1.3400
	2/18/98	CARP	1.0700
	2/18/98	CHANNEL CATFISH	1.8400
	2/18/98	CHANNEL CATFISH	1.7700
	2/18/98	WHITE BASS	1.1400
	8/22/05	CARP	1.9458
	8/22/05	CHANNEL CATFISH	0.1510
	8/22/05	WHITE BASS	0.3206

Table B-3. Fish Tissue Monitoring Data for PCBs

Monitoring Station ID	Date	Fish Species	PCB 1260 [mg/kg]
MISSI724.6SH	11/22/91	BLUE CATFISH	0.195
	11/22/91	BLUE CATFISH	0.200
	11/22/91	BLUE CATFISH	0.195
	11/22/91	BLUE CATFISH	0.195
	11/22/91	BLUE CATFISH	0.200
	11/22/91	CHANNEL CATFISH	0.200
	11/22/91	SMALLMOUTH BUFFALO	0.195
	11/22/91	SMALLMOUTH BUFFALO	0.195
	11/22/91	SMALLMOUTH BUFFALO	0.195
	11/22/91	WHITE BASS	0.195
	5/15/95	BLUE CATFISH	0.547
	5/15/95	BLUE CATFISH	0.084
	5/15/95	CARP	0.068
	5/15/95	CARP	0.058
	5/15/95	CARP	0.028
	7/24/96	BLUE CATFISH	0.077
	7/24/96	CARP	0.028
	7/24/96	CHANNEL CATFISH	0.093
	7/24/96	FLATHEAD CATFISH	0.038
	7/24/96	LARGEMOUTH BASS	0.048
	7/24/96	RIVER CARPSUCKER	0.076
	7/24/96	STRIPED BASS	0.140
	10/15/97	BLUE CATFISH	0.325
	10/15/97	CARP	0.111
	10/15/97	CHANNEL CATFISH	0.233
	10/15/97	FLATHEAD CATFISH	0.093
	10/15/97	SMALLMOUTH BUFFALO	0.075
	10/15/97	WHITE BASS	0.160
	11/9/06	BLUE CATFISH	0.330
	11/9/06	CARPSUCKER	0.330
	11/9/06	WHITE BASS	0.360

Table B-3 (cont'd). Fish Tissue Monitoring Data for PCBs

Monitoring Station ID	Date	Fish Species	PCB 1260 [mg/kg]
MISSI735.0SH	11/20/91	CARP	1.020
	11/20/91	CARP	0.177
	11/20/91	CARP	0.255
	11/20/91	CARP	0.099
	11/20/91	CARP	0.289
	11/20/91	CHANNEL CATFISH	0.098
	11/20/91	CHANNEL CATFISH	0.174
	11/20/91	CHANNEL CATFISH	0.142
	11/20/91	CHANNEL CATFISH	0.045
	11/20/91	CHANNEL CATFISH	0.547
	11/20/91	LARGEMOUTH BASS	0.045
	11/20/91	WHITE CRAPPIE	0.046
	9/7/05	BLUE CATFISH	0.072
	9/7/05	BLUE CATFISH	0.034
	9/7/05	SILVER CARP	0.034
	9/7/05	WHITE BASS	0.034
MISSI754.0SH	2/20/92	BIG MOUTH BUFFALO	0.045
	2/20/92	BLUE CATFISH	0.200
	2/20/92	BLUE CATFISH	0.090
	2/20/92	BLUE CATFISH	0.046
	2/20/92	SAUGER	0.046
	2/20/92	SMALLMOUTH BUFFALO	0.190
	2/20/92	SMALLMOUTH BUFFALO	0.109
	2/20/92	WHITE BASS	0.046
	5/16/95	BLUE CATFISH	0.117
	5/16/95	CARP	0.063
	5/16/95	CARP	0.018
	5/16/95	LARGEMOUTH BASS	0.080
	8/5/96	BLUE CATFISH	0.294
	8/5/96	CARP	0.241
	8/5/96	CHANNEL CATFISH	1.290
	8/5/96	LARGEMOUTH BASS	0.394
	8/5/96	LARGEMOUTH BASS	0.191
	8/5/96	STRIPED BASS	0.443
	8/8/96	RIVER CARP SUCKER	0.501

Table B-3 (cont'd). Fish Tissue Monitoring Data for PCBs

Monitoring Station ID	Date	Fish Species	PCB 1260 [mg/kg]
MISSI754.0SH (cont'd)	10/15/97	CARP	0.093
	10/15/97	CHANNEL CATFISH	0.075
	10/15/97	FLATHEAD CATFISH	0.153
	10/15/97	LARGEMOUTH BASS	0.054
	10/15/97	SMALLMOUTH BUFFALO	0.030
	10/15/97	SMALLMOUTH BUFFALO	0.049
	10/15/97	WHITE BASS	0.109
MISSI786.0LE	5/17/95	BLUE CATFISH	0.190
	5/17/95	CARP	0.075
	5/17/95	CARP	0.070
	5/17/95	SMALLMOUTH BUFFALO	0.084
	8/5/96	CHANNEL CATFISH	0.548
	8/5/96	CHANNEL CATFISH	0.543
	8/6/96	CARP	0.289
	8/6/96	CHANNEL CATFISH	5.710
	8/6/96	LARGEMOUTH BASS	0.144
	8/6/96	STRIPED BASS	0.550
	10/14/97	BLUE CATFISH	0.184
	10/14/97	CARP	0.045
	10/14/97	CHANNEL CATFISH	0.097
	10/14/97	SMALLMOUTH BUFFALO	0.045
	10/14/97	WHITE BASS	0.068
	9/7/05	CHANNEL CATFISH	0.034
	9/7/05	CHANNEL CATFISH	0.034
	9/7/05	SILVER CARP	0.010
	9/7/05	WHITE BASS	0.010
MISSI817.8LE	5/18/95	BLUE CATFISH	0.145
	5/18/95	BLUE CATFISH	0.081
	5/18/95	HYBRID BASS	0.170
	5/18/95	SMALLMOUTH BUFFALO	0.104
	5/18/95	SMALLMOUTH BUFFALO	0.139
	8/7/96	CARP	0.453
	8/7/96	CHANNEL CATFISH	0.599
	8/7/96	LARGEMOUTH BASS	0.095
	8/7/96	RIVER CARP SUCKER	0.646
	8/7/96	STRIPED BASS	0.663

Table B-3 (cont'd). Fish Tissue Monitoring Data for PCBs

Monitoring Station ID	Date	Fish Species	PCB 1260 [mg/kg]
MISSI817.8LE (cont'd)	10/13/97	BLUE CATFISH	0.130
	10/13/97	CARP	0.095
	10/13/97	CHANNEL CATFISH	0.094
	10/13/97	FLATHEAD CATFISH	0.308
	10/13/97	SMALLMOUTH BUFFALO	0.075
	10/13/97	WHITE BASS	0.113
	9/7/05	CARP	0.034
	9/7/05	CARP	0.034
	9/7/05	CHANNEL CATFISH	0.034
	9/7/05	CHANNEL CATFISH	0.034
	9/7/05	WHITE BASS	0.034
MISSI873.5LA	2/20/92	BIG MOUTH BUFFALO	0.115
	2/20/92	BIG MOUTH BUFFALO	0.577
	2/20/92	BLUE CATFISH	0.299
	2/20/92	BLUE CATFISH	0.266
	2/20/92	BLUE CATFISH	0.191
	2/20/92	BLUE CATFISH	0.174
	2/20/92	BLUE CATFISH	0.203
	2/20/92	SMALLMOUTH BUFFALO	0.717
	2/20/92	SMALLMOUTH BUFFALO	0.671
	2/20/92	SMALLMOUTH BUFFALO	0.206
	5/19/95	CARP	0.070
	5/19/95	CHANNEL CATFISH	0.171
	5/19/95	HYBRID BASS	0.075
	8/8/96	CARP	0.094
	8/8/96	CARP	0.145
	8/8/96	CHANNEL CATFISH	0.140
	8/8/96	LARGEMOUTH BASS	0.058
	8/8/96	RIVER CARP SUCKER	0.060
	8/8/96	STRIPED BASS	0.079

Table B-3 (cont'd). Fish Tissue Monitoring Data for PCBs

Monitoring Station ID	Date	Fish Species	PCB 1260 [mg/kg]
MISSI873.5LA (cont'd)	2/18/98	BLUE CATFISH	0.170
	2/18/98	CARP	0.077
	2/18/98	CHANNEL CATFISH	0.240
	2/18/98	CHANNEL CATFISH	0.131
	2/18/98	WHITE BASS	0.187
	8/22/05	CARP	0.060
	8/22/05	CHANNEL CATFISH	0.034
	8/22/05	WHITE BASS	0.034

APPENDIX C

Trend Analysis for Chlordane, Dioxins, and PCBs

Fish tissue data were examined over the entire period of record to determine whether any trend could be detected. The value for each sample was plotted and compared to the appropriate target value. (See Appendix A).

Figures C-1 thru C-4 present the total chlordane fish tissue concentrations compared to the target criteria. Exceedance of the target criteria occurred on all segments. In most cases, the highest concentrations appeared to have occurred prior to 1997. Although the data suggests that concentrations may be decreasing, insufficient data was available to determine whether a definite trend existed. Continued fish tissue monitoring is recommended to determine whether any of the segments should be delisted.

Figures C-5 thru C-8 present the total dioxins fish tissue concentrations compared to the target criteria. Exceedances of the target criteria occurred on all segments. The highest concentrations appeared to have occurred prior to 1997. Although the data suggests that concentrations may be decreasing, insufficient data was available to determine whether a definite trend existed. Continued fish tissue monitoring is recommended to determine whether any of the segments should be delisted.

Figures C-9 thru C-12 present the total PCBs fish tissue concentrations compared to the target criteria. Exceedances of the target criteria occurred on all segments. The highest concentrations appeared to have occurred prior to 1997. However, the data do not appear to follow any single trend. Continued fish tissue monitoring is recommended to determine whether fish tissue concentrations are decreasing.

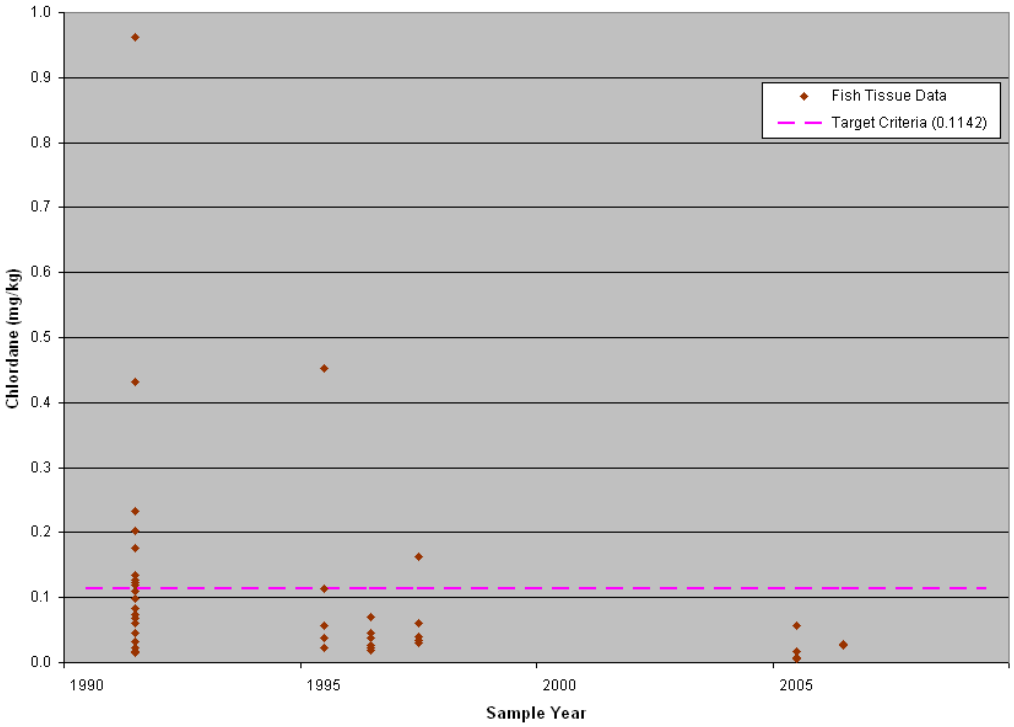

Figure C-1. Total Chlordane Fish Tissue Concentrations for Segment 1000

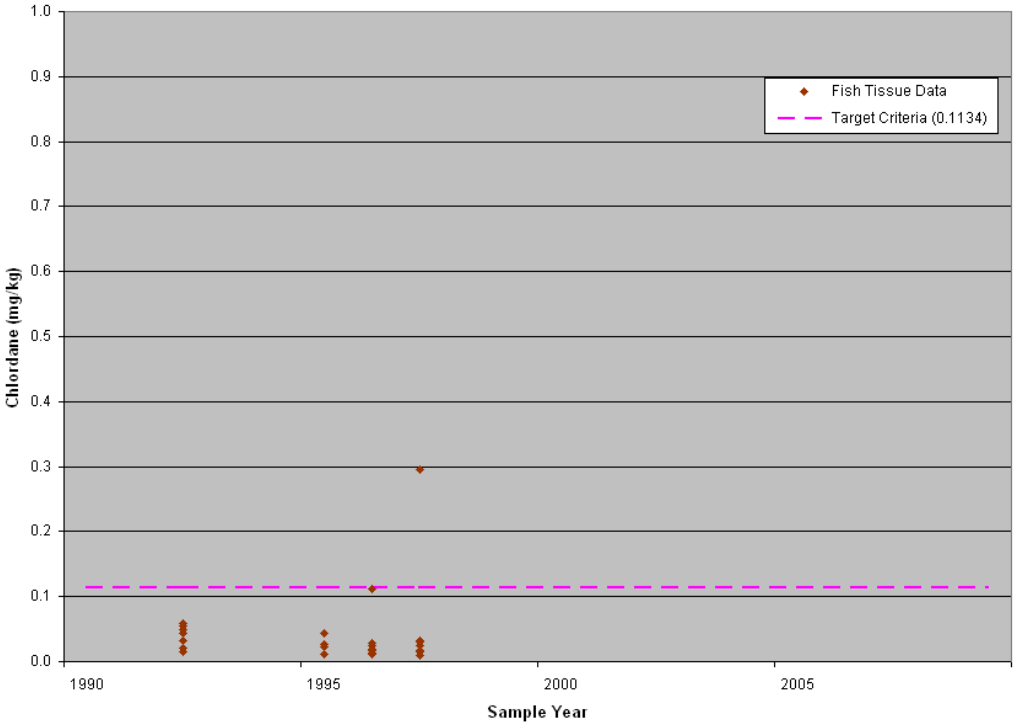

Figure C-2. Total Chlordane Fish Tissue Concentrations for Segment 2000

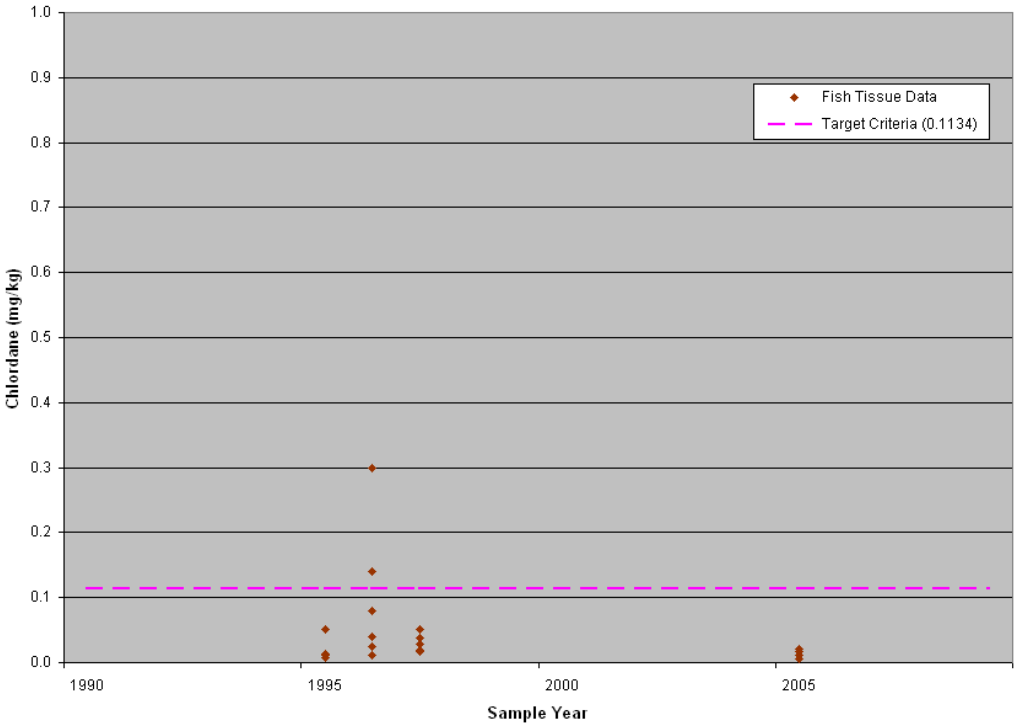

Figure C-3. Total Chlordane Fish Tissue Concentrations for Segment 3000

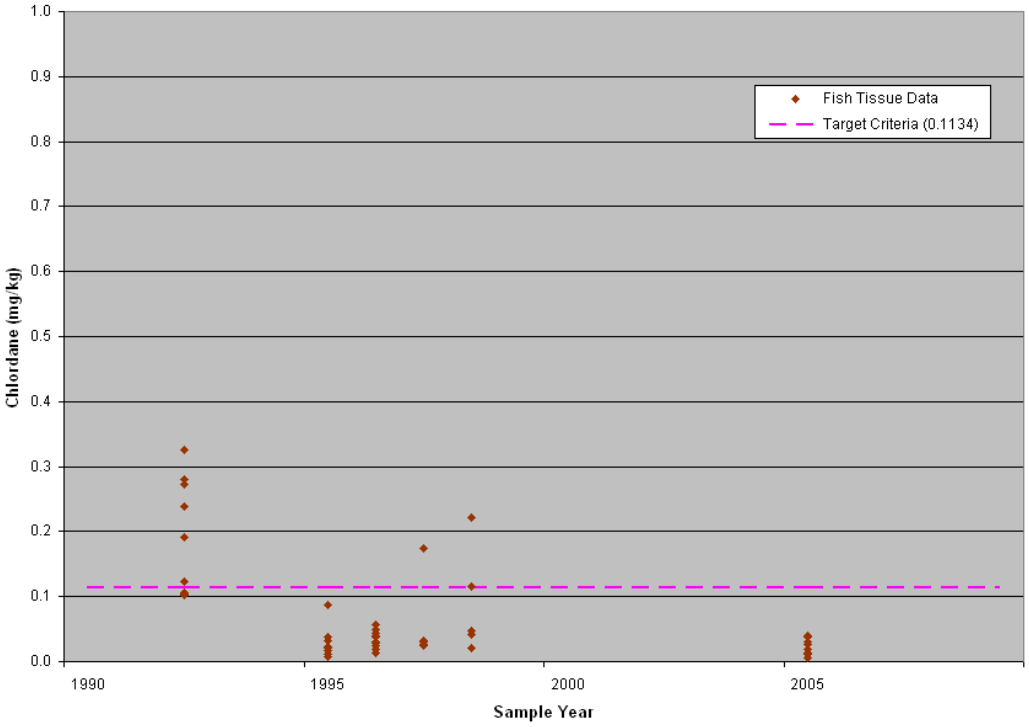

Figure C-4. Total Chlordane Fish Tissue Concentrations for Segment 4000

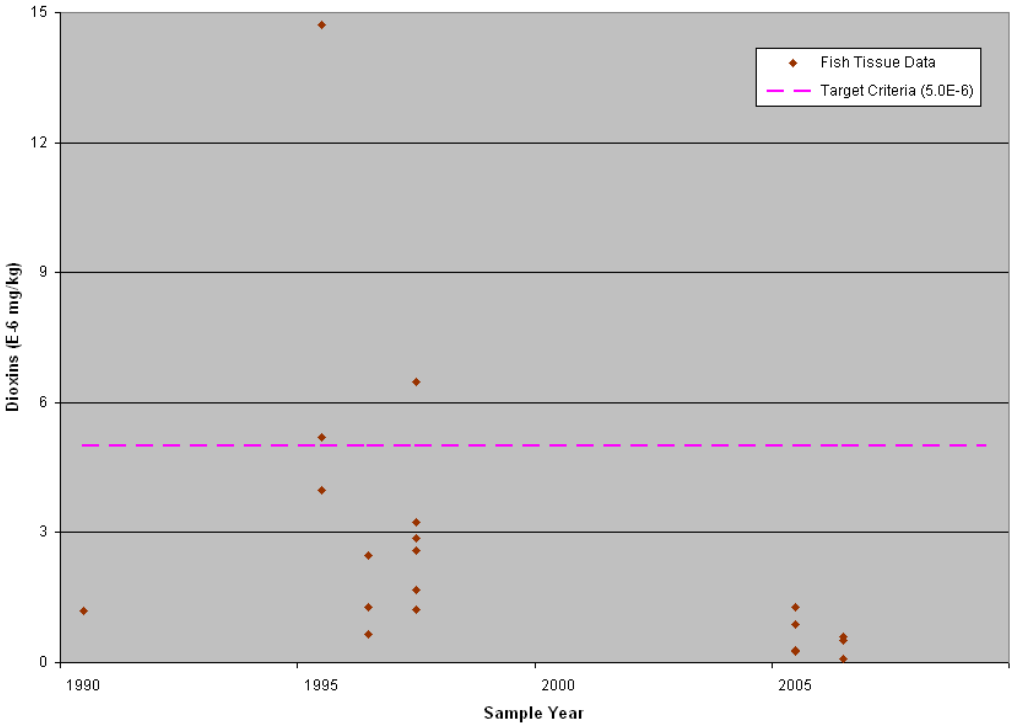

Figure C-5. Total Dioxins Fish Tissue Concentrations for Segment 1000

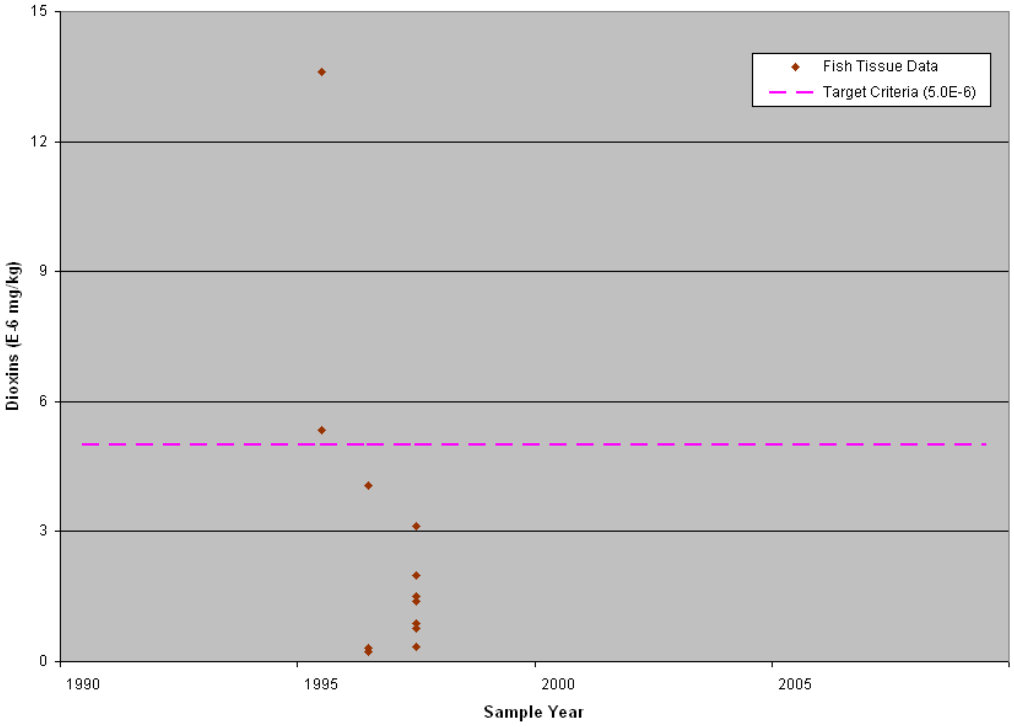

Figure C-6. Total Dioxins Fish Tissue Concentrations for Segment 2000

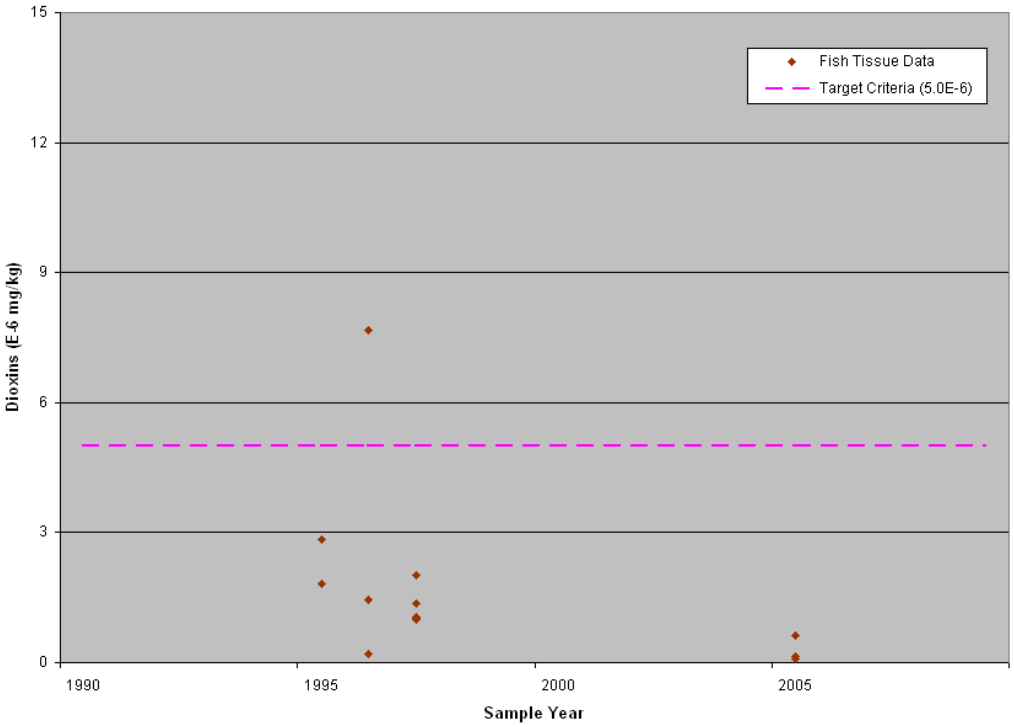

Figure C-7. Total Dioxins Fish Tissue Concentrations for Segment 3000

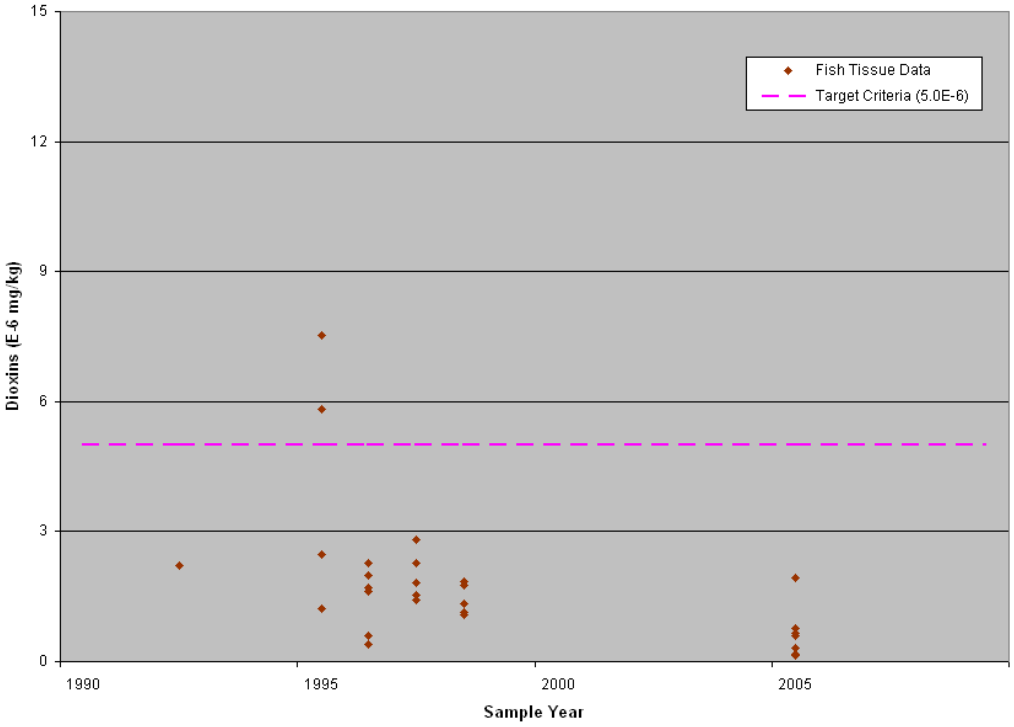

Figure C-8. Total Dioxins Fish Tissue Concentrations for Segment 4000

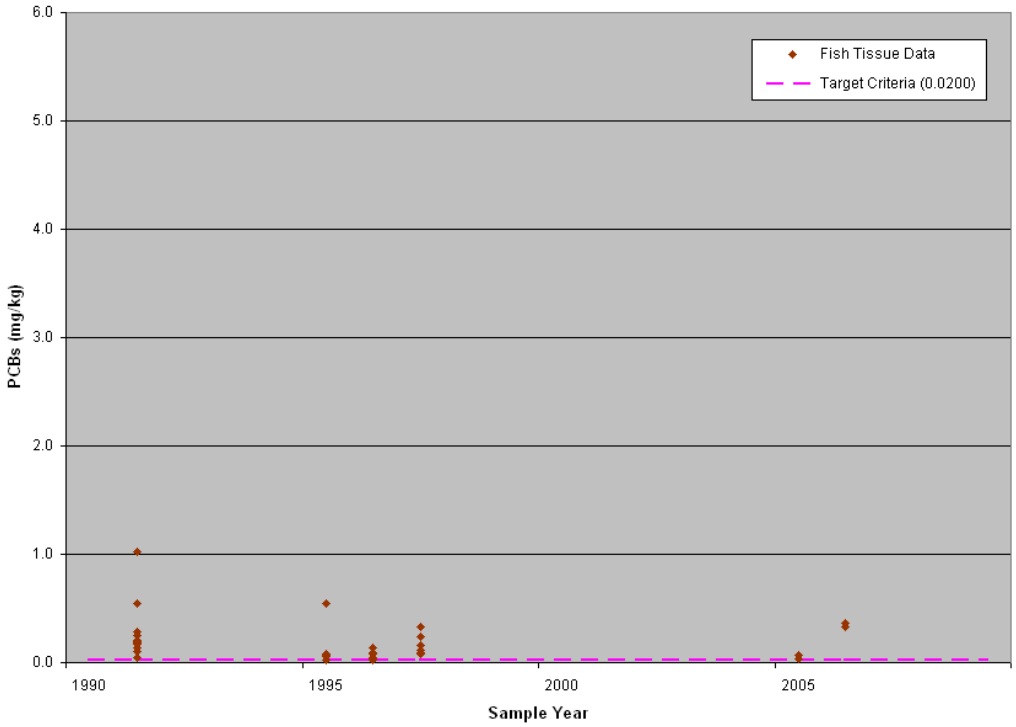

Figure C-9. Total PCBs Fish Tissue Concentrations for Segment 1000

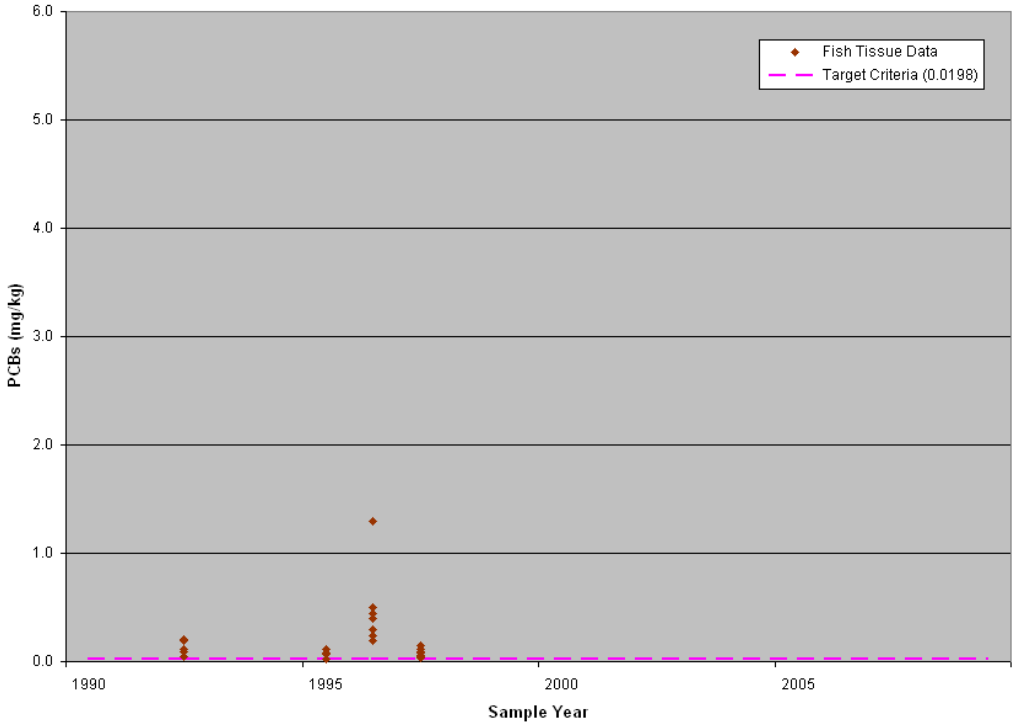

Figure C-10. Total PCBs Fish Tissue Concentrations for Segment 2000

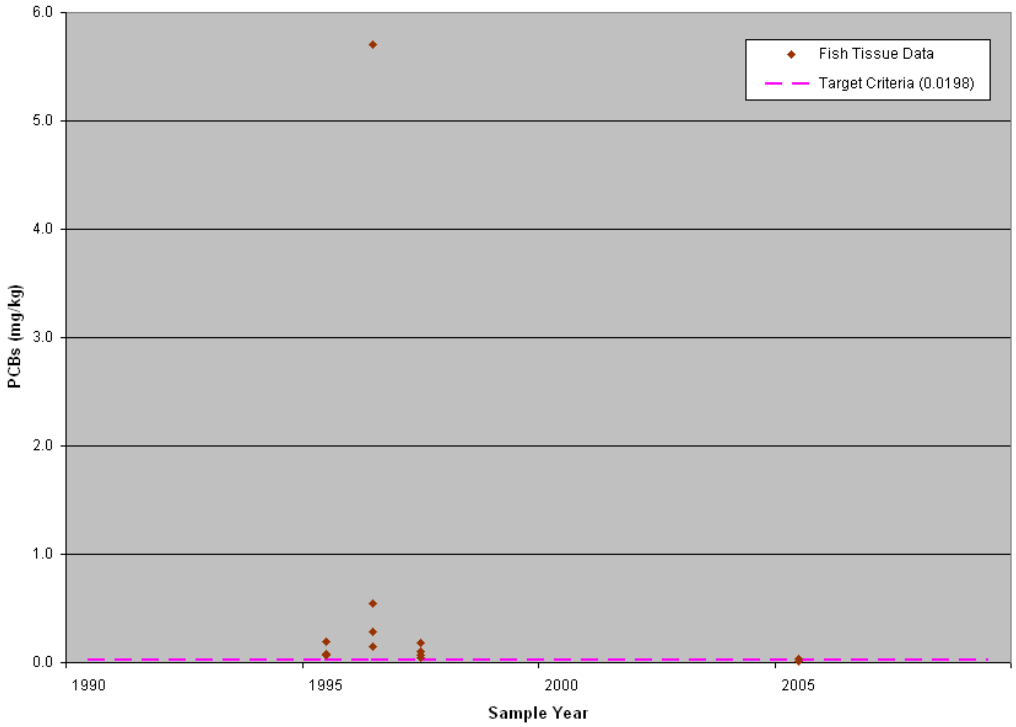

Figure C-11. Total PCBs Fish Tissue Concentrations for Segment 3000

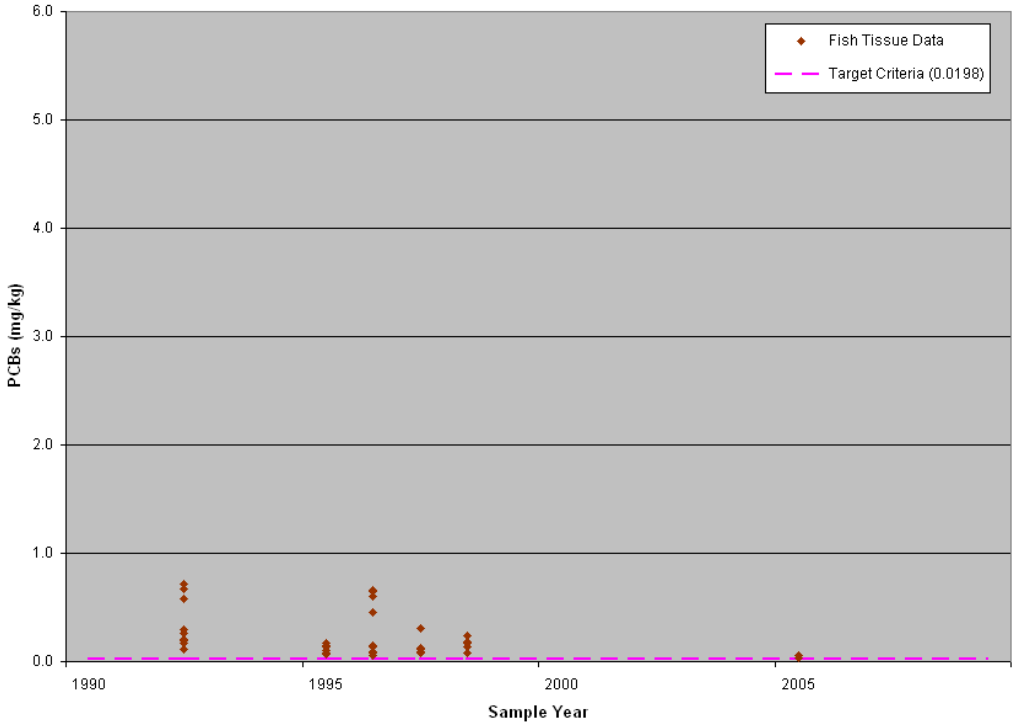

Figure C-12. Total PCBs Fish Tissue Concentrations for Segment 4000

APPENDIX D

Public Notice Announcement

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF WATER POLLUTION CONTROL

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDLS) FOR CHLORDANE, DIOXINS, & POLYCHLORINATED BIPHENYLS FOR THE MAINSTEM OF THE MISSISSIPPI RIVER IN THE MISSISSIPPI RIVER WATERSHED (HUC 08010100), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed Total Maximum Daily Loads (TMDLs) for chlordane, dioxins, and polychlorinated biphenyls (PCBs) for the mainstem of the Mississippi River in the Mississippi River Watershed, located in western Tennessee. Section 303(d) of the Clean Water Act requires states to develop TMDLs for waters on their impaired waters list. TMDLs must determine the allowable pollutant load that the water can assimilate, allocate that load among the various point and nonpoint sources, include a margin of safety, and address seasonality.

The Mississippi River was identified on Tennessee's Final 2006 303(d) list as not supporting designated use classifications due to elevated levels of chlordane, dioxins, and polychlorinated biphenyls (PCBs) in fish tissue samples. Contaminated sediments are the source of pollutant causes associated with these impairments. Using a mass-balance approach, the TMDLs utilize Tennessee's general water quality criteria, fish tissue sampling data collected from the Mississippi River, fish advisory calculations, Bioconcentration Factors defined by the U.S. Environmental Protection Agency, and an appropriate Margin of Safety (MOS) to establish chlordane, dioxin, and PCB loading levels which will result in lower fish tissue concentrations and the attainment of water quality standards.

The proposed chlordane, dioxins, and PCB TMDLs may be downloaded from the Department of Environment and Conservation website:

http://www.state.tn.us/environment/wpc/tmdl/

Technical questions regarding this TMDL should be directed to the following members of the Division of Water Pollution Control staff:

Vicki S. Steed, P.E., Watershed Management Section
Telephone: 615-532-0707

Sherry H. Wang, Ph.D., Watershed Management Section
Telephone: 615-532-0656

Persons wishing to comment on the proposed TMDL are invited to submit their comments in writing no later than June 16, 2008 to:

Division of Water Pollution Control
Watershed Management Section
7th Floor, L & C Annex
401 Church Street
Nashville, TN 37243-1534

All comments received prior to that date will be considered when revising the TMDL for final submittal to the U.S. Environmental Protection Agency.

The TMDL and supporting information are on file at the Division of Water Pollution Control, 6th Floor, L & C Annex, 401 Church Street, Nashville, Tennessee. They may be inspected during normal office hours. Copies of the information on file are available on request.

APPENDIX E

Public Comments Received

Tennessee Chapter, Sierra Club
•
Tennessee Clean Water Network
•
Tennessee Environmental Council

June 12, 2008

Sherry Wang, Ph.D
Watershed Management Section
Division of Water Pollution Control
Tennessee Department of Environment and Conservation
7th Floor, L & C Annex
401 Church Street
Nashville, TN 37243-1534

Re: Proposed Total Maximum Daily Load (TMDL) for Chlordane, Dioxins, and Polychlorinated Biphenyls in the Mississippi River Watershed (HUC 08010100)

Dear Dr. Wang:

These comments are submitted (as Attachment 1) on behalf of the Tennessee Clean Water Network, the Tennessee Chapter of the Sierra Club, and the Tennessee Environmental Council regarding the proposed Total Maximum Daily Load (TMDL) for Chlordane, Dioxins, and Polychlorinated Biphenyls (PCBs) in the Mississippi River Watershed, dated May 12, 2008. We appreciate the opportunity to comment on the preliminary draft of the proposed TMDL and look forward to the inclusion of these concerns in the revisions to the final draft of the TMDL.

There are some positive elements in the proposed TMDL for the Mississippi River for which we applaud your efforts. However, we do not believe the proposed TMDL satisfies federal regulations primarily due to the lack of both demonstrated evidence of sources and an implementation plan to address the pollutants of concern.

We provide these comments in an effort to ensure the most protective strategies are taken to improve the water quality of the Mississippi River. Please make a thorough consideration of the following comments and incorporate these concerns into the final development of a TMDL for the Mississippi River. We look forward to working with you in these important efforts to improve Tennessee's water quality.

Sincerely,

Renée Victoria Hoyos, Executive Director
Tennessee Clean Water Network

John McFadden, Executive Director
Tennessee Environmental Council

Axel C. Ringe, Water Quality Committee Chair
Tennessee Chapter, Sierra Club

Cc: Paul Gagliano, TMDL Coordinator for Tennessee, USEPA Region 4

Attachment 1

Comments and Review of the Proposed Total Maximum Daily Load for Chlordane, Dioxins, and PCBs in the Mississippi River Watershed (HUC 08010100)

1. Identification of the Waterbody, Pollutant of Concern, Pollutant Sources and Priority Ranking

- The document fails to discuss the priority ranking of the Mississippi River or the divided segments. The priority rankings must be discussed within the TMDL.
- Point Sources
  - The document fails to identify the number of NPDES permits located within the watershed. Each NPDES permit holder in the watershed should be listed.
  - The document fails to identify the likely impact of NPDES permitted facilities (page 16 of 24). While the document acknowledges there are no permitted discharges for any of the pollutants of concern, there is no evaluation of a possible connection of the point source facilities and the pollutants. There is a lack of demonstration the NPDES permit holders are not contributing to the pollutants of concern. Along with each listed NPDES permitted facility the discharge potential for each facility should be provided for all pollutants relevant to the TMDL discussing the presence or absence of effluent limits and monitoring requirements as well as the results for any with possible relevant discharges.
  - Neither the locations nor the quantities of the pollutants of concern are addressed in this section. The TMDL must include source location and quantity of each pollutant.
  - We request the self-monitoring storm water data for Chlordane and other pesticides analyzed for Velsicol Chemical Corporation's Storm Water Multi-Sector Permit (TNR051057) be provided in the appendices of this TMDL, and that all the Chlordane data for Velsicol's previous storm water permit, known as the Baseline General Permit (TNR001057) be included as well.
- Non-point Sources
  - There is a significant lack of evidence or demonstration of sediment as primary the source of the pollutants of concern or that other states are a major contributor (page 16 of 24). The TMDL claims "assessments have determined that contaminated sediments and sources in other states are the source" of the three pollutants. However, no further information is provided. There is no scientific data provided to support this claim. The TMDL must demonstrate the source of these pollutants and also provide the quantity for each pollutant of concern.
  - While a reference is made to Arkansas and Missouri (page 16 of 24), this TMDL does not take into consideration cross-border effects on the part of Tennessee. This TMDL must take into consideration the designated uses and water quality standards of cross-stream states.
  - This document fails to demonstrate that current and former National Priorities List sites mentioned (page 16 of 24) are not still contributing to the impairments caused by the pollutants of concern.
- Section 303(d) of the Clean Water Act requires states to adopt TMDLs that take into consideration impacts to downstream water quality. Downstream TMDLs are not discussed in this proposed TMDL. The TMDL for the Mississippi River Basin must address effects to downstream TMDLs of other states and how this TMDL was developed to include meeting the established limits of downstream waterways.

- The document fails to provide any important assumptions made in the development of the proposed TMDL. We request all assumptions regarding future land use, population, wildlife resources, and all other pertinent factors be provided and explained.

2. Description of Applicable Water Quality Standards and Numeric Water Quality Target

- There is no discussion regarding the applicable water quality standards, designated uses, nor water quality criteria. We request they be addressed.
    - The summary sheet merely lists the stream segments and lengths and designated uses, but provides no discussion to the TMDL development process or correlation to the proposed TMDL determinations (page v). The TMDL must include a description of the water quality standards, designated uses, and water quality criterion (40 CFR § 130.7(c)(1)).
- The antidegradation policy of the state is not addressed. The TMDL must discuss any relevance of these three pollutants to the state's anti-degradation policy.
- The relationship between necessary reductions of the pollutants of concern and attainment of water quality standards is not addressed. This correlation must be included in the TMDL.

3. Loading Capacity – Linking Water Quality and Pollutant Sources

- The proposed TMDL does not provide the loading capacity for each pollutant. This information must be included in the TMDL (40 CFR § 130.2(f)).
- The document lacks an explanation of the methodology employed to establish a cause and effect relationship between the numeric target and the identified pollutants sources. The existence of a cause and effect relationship is nonexistent in the proposed TMDL because the sources of the pollutants are not demonstrated. Evidence of the source must first be identified and then a cause and effect relationship must be established between the demonstrated sources and numeric target. Then the methodology for this process must be documented.
- There is no documentation supporting the proposed TMDL analysis. The document does not provide a basis for any assumptions, nor does it evaluate the strengths and weaknesses in the analytic process.
- The proposed TMDL does not define the applicable critical conditions, nor describe the approach taken to estimate point and non-point source loadings (page 18 of 24). The single reference to critical conditions claims analysis covering a period of the previous 27 years, but provides no further information. The applicable critical conditions must be included.
- The proposed TMDL fails to discuss aspects of loading capacity for the watershed and fails to make a link between the water quality and presumed pollutant sources, which must be included per regulations.

4. Wasteload Allocations (WLAs)

- Since the proposed TMDL failed to identify NPDES permit holders within the watershed, or any other potential point sources for the pollutants of concern, the loading capacities are not provided. The document assumes a WLA of zero without fully evaluating and demonstrating the connection or lack of connection of pollutants loads to point sources (page 18 of 24).

- The document fails to address potential future point sources, which must be included in the TMDL in order to establish accurate WLAs (40 CFR § 130.2(h), 40 CFR § 130.2(i)).

5. Load Allocations (LAs)

- Sediment and other states are listed as the only nonpoint source of pollutant loading, however they are not demonstrated as the primary or sole sources of the pollutants of concern. Therefore the proposed TMDL is assuming all loads are from nonpoint sources (page 18 of 24), but does not breakdown the LAs to particular sources.
- The natural background is not assessed any portion of the LA. There is no discussion of the natural background in the proposed TMDL. This must be included.
- The document fails to address potential future nonpoint sources, which must be included in the TMDL in order to establish accurate LAs.

6. Margin of Safety (MOS)

- The proposed TMDL uses an implicit method of incorporating the MOS (page 18 of 24), but does not provide evidence to support the assumptions. Therefore the MOS is not demonstrated exist.

7. Seasonal Variations

- The proposed TMDL was established based upon fish tissue samples collected during a variety of season (page 18 of 24), but there is no justification for this collection method.
    - The document failed to provide evidence sediment is the primary source of pollutant loading, and therefore does not justify the collection method.
    - The collection method did not take into account the claim that the other nonpoint sources were from other states, which may be affected by seasonal variations.

8. Reasonable Assurances

- There is no information regarding reasonable assurances in the proposed TMDL.
- The proposed TMDL fails to address the potential impact from point source pollutants, and therefore no reasonable assurances are provided to prevent point source loading.
- There are no reasonable assurances the nonpoint source measures will achieve expected load reductions. There is no demonstration the proposed actions will reduce the nonpoint source loads from impacting water quality.

9. Monitoring Plan to Track TMDL Effectiveness

- While the proposed TMDL does acknowledge the TMDL effectiveness will be assessed when "data become available or when necessary" (page 20 of 24) there is no monitoring plan provided.
    - Neither a timeline nor a schedule of monitoring events is established. The "water quality assessment cycles" are not described.
    - A valid monitoring plan is required and must be provided in the TMDL. This plan must include how monitoring will be conducted, where monitoring sites are to be located, and how frequently monitoring is to occur. We request this also include the entities or agencies responsible for data collection and reporting.

10. Implementation

- There is no implementation plan provided in the proposed TMDL. The proposed TMDL claims only two options are available (page 20 of 24). The selected option of a wait-and-see strategy is not an implementation plan. There is no demonstration this strategy has provided a measurable decrease in the pollutants of concern, and the proposed TMDL acknowledges this gap.
- An implementation plan must be provided that includes alternatives to the status quo, demonstrated practices to reduce the loading of the pollutants of concern and establishes measurable goals over a specific time period.

11. Public Participation

- The public participation process is clearly established. The Department has been active and diligent in its efforts to notify interested parties and make available the draft TMDL (page 21 of 24).

APPENDIX F

Response to Public Comments

TDEC thanks the Tennessee Chapter of the Sierra Club, Tennessee Clean Water Network, and Tennessee Environmental Council for their interest in reviewing the draft version of this TMDL and their desire to ensure that the most protective strategies are taken to improve the water quality of the Mississippi River. TDEC's response to their comments is summarized below:

1. Identification of the Waterbody, Pollutant of Concern, Pollutant Sources and Priority Ranking

   - As stated in Section 7.1 (page 16 of 24), there are currently **no** permitted point sources authorized to discharge chlordane, dioxins, or PCBs in the Tennessee portion of the Mississippi River Watershed.

   - Monitoring data related to specific permits (such as Velsicol Chemical Corporation) are available online thru USEPA's STORET system: http://epa.gov/storet/dbtop.html .

   - In the future, if TDEC becomes aware of additional sources in the future, the TMDL will be revised to address them. This TMDL deals with known existing sources.

   - As stated in Section 7.2 (page 16 of 24), "assessments have determined that contaminated sediments and sources in other states are the most significant source of chlordane, dioxin, and PCB impairments in five segments of the Mississippi River." These assessments were conducted prior to including the Mississippi River in the 1998 303(d) List. No scientific data has become available since that time to suggest other more significant sources. In fact, according to the USGS (Contaminants in the Mississippi River – Executive Summary, U.S. Geological Survey Circular 1133), "many toxic chemicals, including most heavy metals and the majority of the USEPA Priority Pollutants, are primarily associated with sediments."

   - TMDLs developed by TDEC are based on Tennessee's Water Quality Standards (WQS). TDEC believes that Tennessee's WQS are sufficiently protective of human health and the environment. None of the downstream states have included the Mississippi River in their state's 303(d) List or established TMDLs for chlordane, dioxins, or PCBs. Any reduction in contaminant concentrations due to Tennessee's TMDL will only improve downstream water quality.

   - The portion of Section 7.2 dealing with NPL listings has been expanded. Note that none of the NPL sites mentioned are located in the Mississippi River Watershed, but are located in watersheds that drain to the Mississippi River Watershed. Further details regarding individual NPL sites is available at: http://www.epa.gov/superfund/sites/npl/tn.htm .

   - Priority rankings are discussed and assigned as part of the 303(d) listing process. Priority rankings are a means of determining when a TMDL will be developed.

2. Description of Applicable Water Quality Standards and Numeric Water Quality Target

   - Applicable water quality standards, designated uses, and water quality criteria are discussed in Appendix A – Development of Target Criteria for Chlordane, PCBs, and Dioxins.

   - This TMDL was developed to ensure compliance with Tennessee's Water Quality Standards. The TMDL is not in conflict with the antidegradation portion of the Water Quality Standards.

   - The TMDL is expressed as a function of flow (Q_n), the water quality standard for the designated use classification, and a conversion factor. When a waterbody meets the calculated TMDL value, it will also have attained the water quality standard.

3. Loading Capacity – Linking Water Quality and Pollutant Sources

   - The TMDL is the loading capacity. TMDL (loading capacity) for each pollutant/waterbody combination is included in the Summary Table and in Table 5.

   - Research conducted by USGS (Contaminants in the Mississippi River, U.S. Geological Survey Circular 1133) has determined that PCBs are typically most concentrated on the suspended sediments in the Upper Mississippi River near Minneapolis-St. Paul. Although banned for many years, PCBs still persist in the bottom sediments in the pools of the Upper Mississippi River.

     According to the USGS (Contaminants in the Mississippi River, U.S. Geological Survey Circular 1133), the majority of all pesticides used in the Mississippi River Basin are applied in the upper part of the basin. Consequently, streams draining Illinois, Iowa, Indiana, eastern Nebraska, and southern Minnesota contribute the largest quantities to the Mississippi River.

   - Monitoring by means of fish tissue sampling addresses long-term issues, including critical conditions and seasonal variation (see #7).

4. Wasteload Allocations (WLAs) and 5. Load Allocations (LAs)

   - A WLA of zero has been assigned to all point sources.

   - Potential future point sources are addressed in footnote 2 of the Summary Table and Table 5.

   - All of the pollutants addressed in this TMDL are synthetic (man-made) chemicals. There is no natural background level for man-made chemicals.

   - This TMDL was developed using readily available information. When additional information related to nonpoint sources becomes available, the TMDL will be revised to include a more detailed allocation for particular nonpoint sources.

6. Margin of Safety (MOS)

   - TDEC has revised the TMDL to reflect a 5% explicit margin of safety.

7. Seasonal Variation

   - According to Tennessee's 2008 305(b) Report, "fish tissue samples are often the best way to document chronic low levels of persistent contaminants". Fish tissue monitoring in Tennessee is planned by a workgroup consisting of staff from TDEC, TVA, TWRA, and ORNL.

8. Reasonable Assurances

   - As stated in Section 7.1 (page 16 of 24), there are currently no permitted point sources authorized to discharge chlordane, dioxins, or PCBs in the Tennessee portion of the Mississippi River Watershed. US production of PCBs ended in 1976 and chlordane was banned for all uses in 1988. "Overall, there is no reason to expect that the levels of chlordane and PCBs in the environment, and therefore chlordane and PCB levels in fish tissue, will do anything but decline in the future." The WLA developed as part of this TMDL ensure that point sources are not allowed to contribute to exceedances.

9. Monitoring Plan to Track TMDL Effectiveness

   - Future monitoring will continue to be based on fish tissue sampling. Monitoring will continue at the same sites as before in order to permit trend analysis. As with other waterbodies in Tennessee, monitoring follows a 5-year watershed cycle. Additional information about Tennessee's watershed approach is available at: http://www.tennessee.gov/environment/wpc/watershed/ .

10. Implementation

    - TDEC implementation strategy is discussed in detail in Section 9.

11. Public Participation

    - Thank you.